WAVETEK

INSTRUCTION MANUAL

MODEL 2405/2410A

SIGNAL GENERATOR

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REV. B
Manual Part No.
6510-00-0007

MP MASTER
MA24946

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SECTION 1
GENERAL INFORMATION

1.1 INTRODUCTION

The Wavetek Model 2405/2410A is a dual microprocessor controlled, synthesized signal generator that covers the frequency range of 10 kHz to 1100 MHz. It has an output power level continuously adjustable from +13 dBm to -127 dBm. In addition to CW operation, it is capable of AM/FM operation from an internal or external source. The 2405/2410A has a very broad 500 kHz to 1 MHz peak FM deviation over the majority of its operating range. Standard features include an exclusive AutoCal® self-calibration function for frequency and amplitude, extensive user diagnostics, an automatic power up test sequence, and 20 nonvolatile memory locations to store front panel settings. A 10 MHz sine wave reference output is available at the rear panel.

A talk/listen GPIB fully conforming to the IEEE-488 standard is standard for the Model 2405/2410A. Because it utilizes the minimum uniqueness concept, the 2405/2410A is easily conformed to any ATE system. It is fully compatible with the entire Wavetek 2500 family of instruments.

All operational controls are located on the front panel. Controls include keypad switches for entry of all RF output numeric parameters. A 4-key cursor provides increment/decrement entry of numeric data in digit steps, with any displayed digit selectable as the digit around which changes occur. Instrument settings and operational status are indicated on a two-line LCD display.

The 2405/2410A is a space-saving 3/4-rack size. (Two optional rack mount adaptor kits are available.)

1.1.1 FREQUENCY CHARACTERISTICS

The carrier frequency may be set from 10 kHz to 1100 MHz with .1 Hz resolution and .00025% (2.5 ppm) accuracy. Frequency aging is <1 ppm/year.

1.1.2 MODULATION CHARACTERISTICS

The instrument features both internal and external AM and FM capabilities. The internal modulation source may be set at a 400 or 1000 Hz rate. AM depth is specified from 0 to 100%. FM deviation can be set at peak values from 10 kHz to 1 MHz, depending upon the output frequency (see section 1.2.7.2). An external signal ≥ .5vpp at 10 MHz may be used as an external reference input.

Internal and external sources may be used simultaneously to produce complex modulation.

1.1.3 OUTPUT LEVEL CHARACTERISTICS

The Model 2405/2410A has an RF output range of + 13 dBm to -127 dBm with an accuracy of ± 1.5 dB of the actual measured level. Level resolution is .1 dB.

Output level may be read in dBm, dBmV, dBμV, mV, or μV. Reverse power protection to 50 watts is standard.

1.1.4 AutoCal®/DIAGNOSTICS

The Model 2405/2410A utilizes a unique AutoCal® routine to perform a quick and easy almost completely automatic self-calibration. The routine is software controlled, menu driven, and activated from the front panel. A variety of other menu driven diagnostic/control programming aids are standard with the 2405/2410A.

1.1.5 STORED SETTINGS

Nonvolatile memory locations allow up to 20 complete front panel settings to be stored and recalled in any order. This storage permits fast and accurate recall of frequently used settings.

The 2405/2410A powers up with the same settings present when power was removed, except the RF output will be off.

1.1.6 ERROR INDICATORS

The 2405/2410A front panel display indicates the following error conditions:

- An unlocked condition in the phase locked loop circuitry
- An unleveled condition in the RF output leveler circuitry
- A tripped RF circuit breaker
- Modulation frequency reference error

1.2 SPECIFICATIONS

1.2.1 FREQUENCY

RANGE	10 kHz to 1100 MHz
RESOLUTION	.1 Hz; digital readout
STABILITY, 0-50° C	.00025% (2.5 ppm)
STABILITY, AGING	<1 ppm/year
SWITCHING TIME	200 ms (± 100 Hz of final value in CW and for changes <10 kHz in FM); typically 100 ms
REFERENCE	
INTERNAL	10 MHz
EXTERNAL	Accepts 10 MHz ≥.5 Vp-p

1.2.2 RF OUTPUT

LEVEL RANGE	+13 to -127 dBm (1 volt to 0.1 microvolt)
LEVEL RESOLUTION	0.1 dB
LEVEL ACCURACY	± 1.5 dB of set output level
LEVEL FLATNESS	± 1 dB
OUTPUT IMPEDANCE	50 W with VSWR <1.5:1 at RF outputs <-3 dBm
OUTPUT CONNECTOR	Type "N", female
EMI/RFI LEAKAGE	<1 µV into a 2-turn 1 inch diameter loop held one inch from any surface at 550 MHz

1.2.3 SPECTRAL PURITY

HARMONICS	<-30 dBc for CW frequencies >10 MHz <-26 dBc for CW frequencies <10 MHz
SUBHARMONICS	<-25 dBc for CW frequencies >550 MHz
SPURIOUS	<-50 dBc for offset >5 kHz from carrier

1.2.4 PHASE NOISE @ 500 MHz	10 kHz offset ; <-107 dBc/Hz guaranteed
1.2.5 RESIDUAL AM	<-60 dBc (50 Hz to 15 kHz post detection bandwidth)
1.2.6 RESIDUAL FM (50 Hz to 15 kHz post detection bandwidth)	<30 Hz rms (<137.5 MHz) <12.5 Hz rms (137.5 - 275 MHz) <25 Hz rms (275 - 550 MHz) <50 Hz rms (550 - 1100 MHz)

1.2.7 MODULATION

MODES	AM, FM, COMPLEX (EXT AM and INT FM; EXT FM and INT AM)
INTERNAL SOURCE	400 Hz, 1 kHz; derived from frequency standard
EXTERNAL SOURCE	Front Panel Modulation in jack
AM MODE	10 Hz to 50 kHz frequency response, 600 Ω input. Input Level 1 volt peak-to-peak into 600 Ω for full scale modulation
FM MODE RANGES	50 Hz to 100 kHz frequency response, 600 Ω input. 0 to 1 MHz (3-137.4999999 and ≥275 MHz); 0 to 500 kHz (137.5-274.9999999 MHz); 0-100 kHz (1-3 MHz); 0-10 kHz (.01-1 MHz)
DEVIATION ERROR	± 5% of indicated setting at 1 kHz or 400 Hz rate, excluding residual FM
DISTORTION INTERNAL SOURCE	<2% harmonic distortion at 1 kHz or 400 Hz rate; FM <100 kHz peak
EXTERNAL SOURCE	<0.5% at 1 kHz or 400 Hz rate; FM <100 kHz peak

1.2.7.1 AM CHARACTERISTICS

AM FREQUENCY RESPONSE	3 dB BW from 10 Hz to 50 kHz (50% modulation)
AM RESOLUTION	.1%
AM RANGE	0 - 100%
MODULATION ACCURACY, AM (0 - 90%)	± (1% + 5% of indicated setting) at internal rates
AM DISTORTION	<1.5%, below 30% modulation; internal rates <3%, 30% to <70% modulation; internal rates <5%, 70% to <90% modulation; internal rates

1.2.7.2 FM CHARACTERISTICS

FM RESOLUTION	100 Hz (deviations <100 kHz) 1 kHz (deviations >100 kHz)
FM FREQUENCY RESPONSE	± 3 dB from 50 Hz - 100 kHz
FM DEVIATION RANGE (1 kHz Rate)	1 MHz peak (3-<137.4999999 & ≥275 MHz) 500 kHz peak (137.5 - 274.9999999 MHz) 100 kHz peak (1 - <3 MHz) 10 kHz peak (.01 - <1 MHz)
MODULATION ACCURACY, FM	At internal rates, ± 5% of indicated setting, excluding residual FM

FM DISTORTION	<2% at internal rates for deviation <100 kHz, excluding residual FM <0.5% at external rates for deviation <100 kHz, excluding residual FM Does not apply during overmodulation conditions

1.2.8 FRONT PANEL CONTROLS

TYPE	Push-button

1.2.9 REVERSE POWER PROTECTION

MAX RF POWER	50 W
TRIP LEVEL	~ .7 W
TRIP TIME	Typically <2 msec
RF CIRCUIT BREAKER	Resettable from front panel

1.2.10 STORED SETTINGS

20 TOTAL, NON-VOLATILE	Complete front panel settings stored

1.2.11 EXTERNAL REFERENCE INPUT (REAR PANEL)

FREQUENCY	10 MHz
REQUIRED INPUT LEVEL	≥ .5 Vp-p
REQUIRED INPUT IMPEDANCE	50 Ω
WAVEFORM	Sine or Square Wave

1.2.12 INTERNAL REFERENCE OUTPUT (REAR PANEL)

FREQUENCY	10 MHz
VOLTAGE OUT/IMPEDANCE	> .5 Vp-p, into 50 Ω

1.2.13 GENERAL

DIMENSIONS	14 cm (5.2 in.) High; 31.75 cm (12.5 in.) Wide; 54.36 cm (21 in.) Deep
WEIGHT	11.79 kg (26 lbs.) net; 13.61 kg (30 lbs.) shipping
POWER REQUIREMENTS	100, 115, 215, or 230 VAC ± 10%; single phase; 50, 60, or 400 Hz; 100 watts, maximum
CALIBRATION INTERVAL	After calibration, the Model 2405/2410A will meet each performance requirement within the tolerance specified for a period of at least 12 months

1.2.14 REMOTE (GPIB) OPERATION	The GPIB permits remote programming of front panel functions. An extended GPIB function permits automatic frequency calibration and board level testing across the GPIB. Command codes conform to TEK codes and formats, Tektronix Standard 80009, Rev. C, 1979.
INTERFACE	GPIB IEEE 488-1978, 1987
CONTROL	All functions except On/Off
FUNCTIONS	T6, L4, SH1, AH1, RL1, DC1, DT1, E2, SR1, TE0, LE0, PP0, C0

1.3 VERSIONS

1.3.1 2405	The 2405 Signal Generator has a frequency range of 10 kHz to 550 MHz. It meets all the specifications listed for the 2410A for the frequency range above. It can have the same options as the 2410A and has the additional option of the Deviation Meter. The standard operation of the instrument is the same as the 2410A. The schematics and the parts list are the same with the deletion of the doubler assembly (1110-00-2354).

1.4 OPTIONS

1.4.1 EXTENDED STORAGE	The extended storage option allows the operator to store into memory and recall 100 complet e front panel settings.
1.4.2 VAR	Variable modulation source replaces internal 1K and 400Hz sources. Includes internal pulse mod source with variable duty cycle.
FREQUENCY RANGE	1 Hz to 100kHz
RESOLUTION	1Hz
ACCURACY	Same as system reference
SINE DISTORTION	< 1%
INTERNAL PULSE MODULATION	
DUTY CYCLE	10 to 90%
RESOLUTION	1%
REP RATE	1 Hz to 10kHz
ACCURACY	± 2.5%
1.4.3 R01 .5ppm REFERENCE	A TCXO is used to maintain stability over 0 to 50 C.
FREQUENCY STABILITY	0.5ppm

	AGING	1ppm/year
1.4.4 R02 .1ppm REFERENCE		A TCXO is used to maintain stability over 0 to 50 C
	FREQUENCY STABILITY	0.1ppm
	AGING	1ppm/year
1.4.5 PUL Pulse Modulation		The PUL option adds a pulse modulator to the 2410.
	RF OUTPUT	+10 to -127dBm
	ON/OFF RATIO	80dB minimum
	RISE AND FALL TIME	25nsec (typ <15ns)
1.4.6 PHM EXTERNAL PHASE MODULATION		The PHM option allows the 2410 to do phase modulation. With phase mod enabled the modulating signal is connected to the FP MOD IN connector. Deviation displayed is related to the phase angle by a formula.
	PEAK PHASE MODULATION	20 rad (3 - 137.5 MHz) 10 rad (137.5 - 275 MHz) 20 rad (275 - 1100 MHz)
	ACCURACY	± 5%
	BANDWITH	50Hz to 50kHz
1.4.7 LEX		The LEX option extends the low frequency output down to 100Hz
	MINIMUM FREQUENCY	100Hz
	MAXIMUM LEVEL	+10dBm
1.4.8 XP		The XP option extends the maximum output power to +23dBm (-25dBc harmonics)
	LEVEL RANGE	+23 to -127dBm
	LEVEL ACCURACY	±1.5dB
	FREQUENCY RANGE	1 to 1100 MHz
1.4.9 Rack Mount Kits		Wavetek manufactures two rack mount adaptor kits, one without slides and one with slides. The rack mount adaptor kit without slides provides a fixed, immovable unit mount. The rack mount adaptor kit with slides allows the unit to be pulled out from the rack. Complete installation instructions are supplied with the hardware for either kit.

SECTION 2
INSTALLATION INSTRUCTIONS

2.1 INTRODUCTION

This section provides complete installation instructions for the Wavetek Model 2405/2410A RF Signal Generator. These instructions include the initial inspection required for the unit and contain information on mechanical installation, electrical installation, and the initial installation checks.

This section also provides packing and storage instructions and environmental restrictions for the unit.

2.2 INITIAL INSPECTION

After unpacking the instrument, visually inspect external parts for damage to connectors, surface areas, etc. The shipping container and packing material should be saved in case it is necessary to reship the unit.

2.2.1 DAMAGE CLAIMS

If the instrument received has been damaged in transit, notify the carrier and either the nearest Wavetek area representative or the factory in Indiana. **Retain the shipping carton and packing material for the carrier's inspection.** The local representative or the factory will immediately arrange for either replacement or repair of your instrument without waiting for damage claim settlements.

2.2.2 PACKING INSTRUCTIONS

Use the original packing material and shipping container to pack the instrument. Observe the following guidelines when using packing materials other than the original ones:

Wrap the instrument in plastic packing material.

Use a double-wall cardboard shipping container.

Use shock-absorbing material on all sides to prevent instrument movement within the container.

Seal the shipping container securely.

Mark all sides, top, and bottom of the shipping container "FRAGILE".

2.3 MECHANICAL INSTALLATION

Mechanical installation instructions are limited to those steps required to install the 2405/2410A into a rack using the optional rack mount adaptor kits available from Wavetek.

Wavetek manufactures two rack mount adaptor kits, one without slides and one with slides. The rack mount adaptor kit without slides provides a fixed, immovable unit mount. The rack mount adaptor kit with slides allows the unit to be pulled out from the rack.

Complete installation instructions are supplied with the hardware for either kit.

2.4 ELECTRICAL INSTALLATION

The instrument can operate from 100, 115, 215, or 230 VAC supply mains, over an AC supply frequency range from 50 to 400 Hz. The rear-panel AC power connector module is set for the operating voltage used, and adjusts the Power Supplies accordingly. The power connector module connects to an AC supply via a line cord with a 3-prong plug. The module contains a time-delay line fuse: 1 A for 100/115 VAC operation; 0.5 A for 215/230 VAC operation. The fuse and a clearly marked voltage selector are accessed when the fuse/voltage select compartment door is open (see Figure 2-1).

Instruments are shipped from the factory set up for 115 VAC operation unless otherwise specified.

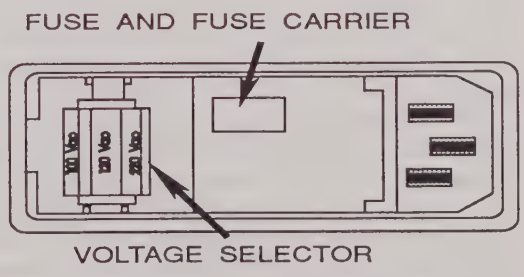


Figure 2-1. AC Power Connector Module

NOTE

Before operating the instrument, check that the rear-panel AC fuse is the correct value for the supply voltage.

2.5 INSTALLATION CHECKS

Wavetek performs a rigorous and complete test/calibration of each 2405/2410A before it leaves the factory. Because accidents can occur during shipment, the user may elect to perform any or none of the following functional checks to further verify proper operation. It is the user's responsibility to determine the degree to which the unit will be tested initially (upon receipt).

Any time power is applied to the Model 2405/2410A, it automatically performs a test sequence to verify various subsystems and subsystem circuitry are functional. The power up test sequence is described in Section 5.5 of this manual.

The following installation check procedures provide a quick functional test to verify that the instrument (total system) is operating properly. If the user desires to verify operation at specification limits, the performance test procedures in Section 4 of this manual must be used.

The functional test procedures involve use of the front panel controls and displays. Controls and displays are described in detail in Section 3 of this manual. Please read Section 3 before initiating operation.

AutoCal®, the almost completely automatic self-calibration procedure for the instrument, is contained in Section 5 of this manual. If it is determined that the unit is not operating properly, perform the AutoCal® procedure, then retest.

2.5.1 REQUIRED TEST EQUIPMENT

The test equipment required to perform the following installation checks will depend upon the degree to which the user wants to verify the instrument. If the desire is to verify to specification, the user should proceed to Section 4 and complete the performance tests detailed there. The installation checks described in the next few paragraphs are intended to provide a functional test of the unit. The operator will verify the output frequency, modulation, and power levels are accurate to the limits of the test equipment used and that the output characteristics change when programmed to change. The following tests are general in nature because the operator may use the test equipment on hand (spectrum analyzer, modulation analyzer, oscilloscope, power meter, etc.) to perform them. Wavetek does not recommend specific test equipment to use for these initial functional tests.

2.5.2 TURN ON

Verify that the voltage selector is set to select the available line voltage, and that the proper fuse is installed (see Section 2.4). Verify that the EXTERNAL/INTERNAL REFERENCE has been selected properly. Selection is made using the reference programming procedures described in section 3.6.5. **If the internal reference source is used, the INT source must be selected.** (If the INT source is not the selected source when the internal reference is used, the power up self test will give an error message and the unit will not operate.) Depress the POWER switch. The display will indicate operation, with the RF OFF. Press the RF ON/OFF key to turn on the RF.

2.5.3 TEST PROCEDURE

The following paragraphs briefly outline a general functional test procedure for the 2405/2410A. Verify measurements to the limits of the test equipment used, if desired.

FREQUENCY: Use the keyboard (Section 3.5.2) to set the output frequency to 1100 MHz at a 0 dBm power level, modulation off. Measure the output frequency. Change the output frequency to 250 MHz. Measure the output frequency. Use the keyboard to set the frequency to 1 MHz. Measure the frequency.

OUTPUT POWER: Set the output frequency at 1 MHz with no modulation. Use the keyboard to set the output power level at +13 dBm. Measure the output power. Set the output power to -3 dBm. Measure the output power. Set the output frequency to 550 MHz. Measure the output power. Use the keyboard to change the output power to +13 dBm. Measure the output power. Set the output frequency to 1100 MHz. Measure the output power. Change the output to -3 dBm. Measure the output power.

AM: Set the output frequency at 1 MHz and power level at -3 dBm. Select INT AM and the 1000 Hz internal source. Set internal AM at 90%. Measure AM. Change the output frequency to 550 MHz. Measure AM. Select the 400 Hz internal source. Measure AM.

FM: Set the output frequency to 275 MHz and the power level at 0 dBm. Select INT FM and the 1000 Hz internal source. Set internal FM deviation at 99.9 kHz. Measure the deviation. Change the output frequency to 1100 MHz. Measure deviation. Select the 400 Hz internal source. Measure FM deviation.

EXTERNAL AM/FM: The user may elect to insert an external modulation source at the EXT REF IN connector on the rear panel (item 2 of Figure 3-2) and repeat the AM and FM tests for EXT AM and EXT FM inputs. Select EXT AM and EXT FM by pressing the appropriate keyboard switch.

2.6 STORAGE INSTRUCTIONS

Store the instrument in a clean, dry environment. Protect the instrument from temperature variations that could cause internal condensation. Store between -40° C to +75° C (-32° F to +158° F) at a relative humidity less than 95% at +25° C.

2.7 ENVIRONMENTAL RESTRICTIONS

The temperature and humidity ranges listed in section 2.6 also constitute the environmental restrictions for this unit.

SECTION 3
OPERATING INSTRUCTIONS

3.1 INTRODUCTION

This section provides complete operating instructions for the Wavetek Model 2405/2410A RF Signal Generator. No preparation for operation is required. The optional initial installation checks contained in Section 2 of this manual may be performed at this time.

The 2405/2410 may be operated locally using the front panel controls or remotely through the General Purpose Interface Bus (GPIB) interface on the rear panel, under computer/controller instructions. The GPIB conforms to proposed IEEE 488.1 and is described in section 6 of this manual.

3.2 AIR FILTER CAUTION

Regularly check the air flow filter installed over the intake vents on the bottom of the unit. Clean or change as necessary. Air filter maintenance is described in the Maintenance Section of this manual.

3.3 FRONT PANEL DESCRIPTION

Front panel operating controls, displays, and connectors are shown in Figure 3-1. All controls necessary for local (manual) operation of the unit are located on the front panel. Front panel features are identified by number in Figure 3-1. Each numbered feature is briefly described in the following paragraph with the same number.

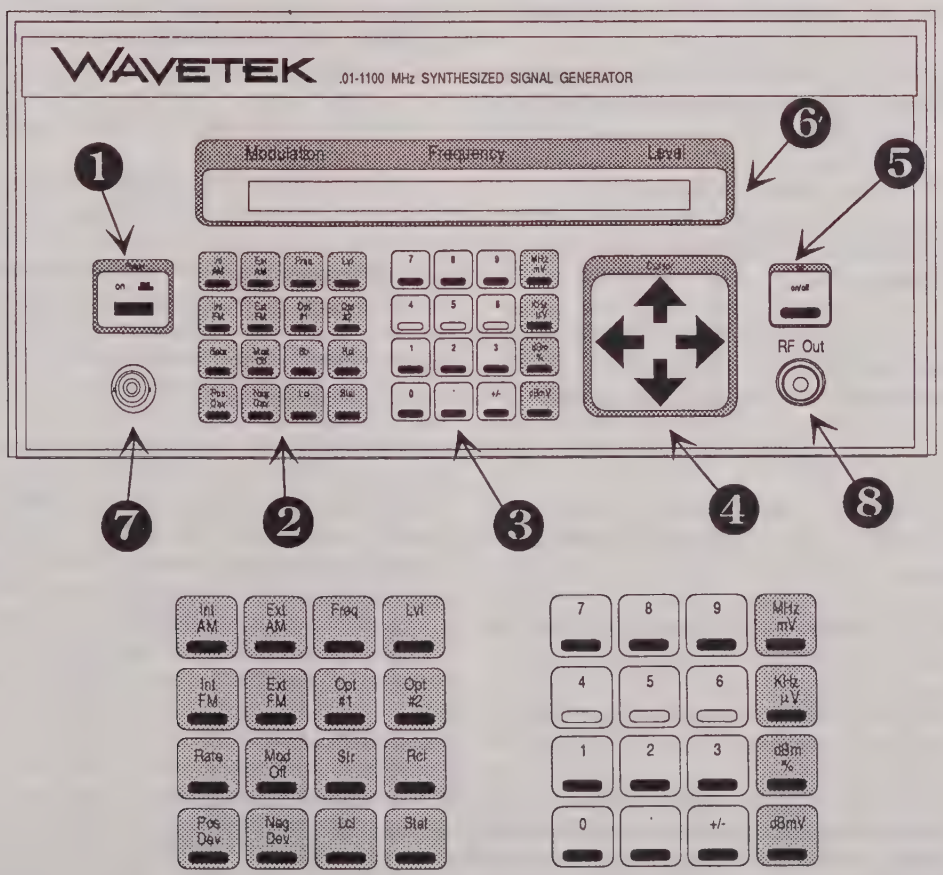


Figure 3-1. Wavetek Model 2405/2410 Front Panel

1.POWER

POWER SWITCH turns on/off the 2405/2410A.

CAUTION

Allow a 2-second time interval between turning power off and on to prevent current surges.

2. FUNCTION CONTROL KEYPAD

FUNCTION CONTROL KEYS are grouped together into a keypad for operator convenience. Each key is described in the following section.

"Int AM" KEY selects the internal amplitude modulation mode of operation and is associated with the Rate key.

"Int FM" KEY selects the internal frequency modulation mode of operation and is associated with the Rate key.

"Ext AM" KEY selects the external amplitude modulation mode. Connect the external amplitude modulation source at the "Mod In" connector (feature 7).

"Ext FM" KEY selects the external frequency modulation mode. Connect the external frequency modulation source at the "Mod In" connector (feature 7).

"Rate" KEY determines which internal source , 400 or 1000 Hz, provides the internal modulation rate (AM or FM, selected by the "Int AM" key or the ""Int FM" key, respectively).

"Mod Off" key turns off all modulation of the carrier wave, selecting an unmodulated CW RF output. This key also turns off the optional deviation meter.

"Pos Dev" KEY is used with the FM deviation meter option.

"Neg Dev" KEY is used with the FM deviation meter option.

"Freq" KEY initiates the procedure to set the RF output carrier frequency.

"Lvl" KEY initiates the procedure to establish the RF output power level.

"OPT" KEYS (2) that are present on the Model 2405/2410A provide operator interfaces for 2405/2410A options. If an option is installed, its associated key will be relabeled. Documentation for future options will be supplied separate to this manual. OPT1 is reserved for external phase mod and OPT2 is reserved for external pulse mod.

"Str" KEY initiates the procedure to store front panel settings in non-volatile RAM (Random Access Memory). There are 20 locations available for stored settings: 00 to 19.

"Rcl" KEY initiates the procedure to recall front panel settings from storage locations in non-volatile RAM.

"Lcl" KEY is used to reestablish front panel control of the 2405/2410A from the remote control source when the unit is in the remote control mode of operation (GPIB). Documentation for the GPIB is provided in section 6 of this manual.

"Stat" initiates LCD menus associated with error messages, diagnostics, options, calibration, control switch setting operations, and the extended GPIB mode (described in Section 6).

3. NUMERIC ENTRY/TERMINATOR KEYPAD

Numeric data is entered using 12 of the 16 keys grouped in this keypad. The digits (0-9) and a decimal point (.) are represented by individual keys. The "+/-" key establishes the sign of an entry (positive or negative) and is the "exit" key for various status key operations described later in this manual.

The "MHz/mV" key terminates an output frequency (MHz) or output level (mV) entry.

The "kHz/mV" key terminates output frequency and FM deviation (kHz) and output level (μV) entries.

The "dBm/%" key terminates output level (dBm) and AM modulation depth (%) entries .

The "dBmV" key terminates output level (dBmV).

Terminator keys also may be used to convert the displayed level value into the units represented by each key. For example, if the display shows output in "dBm", pressing the "Lvl" key and then the "dBmV" key will convert the dBm value displayed to its equivalent dBmV value. Note: The dBmV key is programmable through option selections to function as either dBmV or dBμV.

4. CURSOR

The four cursor keys work together to provide fine and coarse control of output frequency, output level, AM depth (%), and FM deviation (kHz). The keys work in pairs. The left/right arrow keys (resolution digit keys) form one pair. The up/down arrow keys form the other

pair. The operation of each pair is described in the following sections. The cursor keys are only functional when a cursor is displayed on the LCD (by pressing a function key).

The left and right arrow keys act as cursor keys to establish the "resolution" digit in the numeric portion of a displayed function (see item 6). The "resolution" digit is controlled by the up/down keys (see the paragraph immediately following this one). The digits to the left of the resolution digit also are controlled by the up/down keys. The resolution digit is underlined on the display. Pressing the up/down keys will not change digits to the right of the resolution digit.

The up/down keys increase or decrease the numeric value displayed, with the resolution digit as the point around which the change occurs. Pressing the up key will increase the value. The down key will decrease the value.

5. RF ON/OFF

The "RF on/off" key is used to switch the RF signal on and off at the "RF out" connector (feature 8). It is used to reset the reverse power protection circuit breaker when it trips. Also it is used to initiate the extended GPIB mode (described in Section 6).

6. LCD DISPLAY

The front panel display is a two line by forty character, dot matrix, liquid crystal display (LCD). The display provides information about RF output characteristics, indicates operational status of the instrument, and shows readings for the optional deviation meter. The display is divided into various information fields described in the following sections. The top line includes modulation information, frequency information, and level information. The bottom line includes additional modulation information, front panel setting storage/recall information (memory), GPIB and external reference indicators, status information, and the RF on/off indicator. Both lines carry deviation meter information. Many of the numeric values shown on the display will contain the underlined resolution digit used with the cursor (see item 4, Figure 3-1; section 3.3).

The modulation field is the left most twelve characters of the first line of the display. It is identified by the "Modulation" label above the display. It is separated from the next field by one or more blank characters.

The first three characters of the modulation field form a mnemonic that indicates the current modulation input or the last modulation input for complex modulation (AM and FM together). Identical mnemonics are used for front panel and remote (GPIB) operation. Mnemonics for normal operating conditions are:

IAM Internal AM	Options: X0M
External Phase Mod	IFM Internal FM
XPM External Pulse Mod	
XAM External AM	IPM Internal Pulse Mod
XFM External FM	

After a blank space, the next four characters of the modulation field indicate the numeric portion , including decimal point, of the modulation value. The Cursor (see item 4 of Figure 3-1 and see section 3.3) may be used to control these digits. The last three characters show the modulation units (% or kHz). When no modulation (internal or external) is in effect, MOD OFF is displayed.

Note that when in use, the optional deviation meter replaces all internal and external modulation functions. The display will show the positive or negative FM deviation values with the POS or NEG mnemonic, the numerical deviation value, cursor, and the Hz unit. (The first field of the second line on the display will show the characters DEV).

By holding down the "active" modulation key (the current mod being displayed) for more than one second, the top display line will be replaced by a series of mnemonics indicating all of the modulation sources currently enabled. The normal display information will be restored when the key is released.

The frequency field is on the first line of the display, below the "Frequency" label. It consists of characters 14 through 28 on the line and is separated from the modulation field by one or more blank spaces. The numeric value of the frequency, including decimal point, is shown in the first twelve characters. The Cursor (see item 4 of Figure 3-1 and see section 3.3) may be used to control these digits. The last 3 characters contain the "MHz" units.

The level field is composed of the last ten characters on the first line of the display. These characters are located under the "Level" label. Two blank spaces separate this field from the frequency field. The first character in the level field is the plus or minus sign for level in dBm. The next five characters show the numeric value of the level, including decimal point. The Cursor (see item 4 of Figure 3-1 and see section 3.3) may be used to control these digits. The last characters are dedicated to the level units (dBm or mV or µV or dBmV or dBm µV).

The first eleven characters on the second line give the internal rate in Hz (either 1000 or 400). When no internal modulation is used, no internal rate is displayed. If the variable mod rate option is installed, the value will be

displayed from 1 Hz to 100 kHz in 1 Hz resolution. A cursor will be displayed when the RATE key is first pressed.

When the optional deviation meter is in use, the characters DEV replace the modulation rate status shown in this field.

When instrument settings are loaded into (stored) or recalled from memory locations, the location for storage or recall is shown under the Frequency label on line two of the display. Typical store/recall indications are STORE 11 and RECALL 11, for example. When a setting is changed and no longer represents the contents of a particular location, the location information is removed. The Cursor (see item 4 of Figure 3-1 and see section 3.3) may be used to increment or decrement the recall operation.

When the instrument is controlled across the GPIB bus (remote operation), this field will show the indication REMOTE. If it is returned to front panel operation, LOCAL will be displayed.

The third field on the second line displays XREF when an external reference is used. IREF is shown when the internal reference (default condition) is used.

The fourth field on the second line contains the pulse mod status if that option is installed and enabled, "XPM on" will be displayed if external pulse mod is enabled, "IPM on" will be displayed if internal pulse mod is enabled (mutually exclusive). If the option is not installed, or is installed but is not enabled, this field is blank. Pulse mod selections are made by the Pulse mod key and in the settings menu (refer to the Options section).

This display field doubles as an indication of the error status of the instrument. An error condition will be indicated by the STATUS message that will flash on and off. The STATUS error message will continue to flash on and off until the Status (Stat) key (item 2 of Figure 3-1; section 3.3) is pressed, or the error condition no longer exists.

After the STATUS request is acknowledged by pressing the "Stat" key, the second display line will show the following message:

1: ERROR 2:DIAG 3:OPTN 4:CAL 5:SET +:EXIT

This is the status key operation select menu. It shows the available status key operations. The status key is used to initiate error reporting, diagnostics, options, calibration, and control switch setting operations. ERROR represents error reporting operations. DIAG stands for diagnostic test procedures. OPTN is the option review and programming procedures. CAL stands for calibration procedures. SET is the control switch setting operations. To initiate the status key operation shown, enter its associated number. The appropriate menu will be called up. The cursor is initially located under the "E" in "ERROR", as shown above. Pressing the STATUS key is like pressing the "1" key in this instance. The first in the series of Error Reporting menus will be generated (see section 3.6.1).

Pressing the "+/-" key from the status key operation select menu will restore the normal operating display. If internal or external pulse mod is enabled, the pulse mod status display will be restored, otherwise the "STATUS"' message will be displayed (not blinking) if the error still exists or the field will be blank if not.
Status key operation incorporates user friendly LCD menus that guide the operator through the procedures associated with the status key. CAL (Calibration) operations are described in Section 5.3 of this manual. The remaining status key operations are described in sections 3.6.1 through 3.6.5.

The last field in the second line shows the status of the RF output. It will indicate RF on or RF off. This information is always present on the display.

7. MODULATION IN CONNECTOR

The "Mod In" connector is a BNC connector to which an external modulation source or the input for the optional deviation meter will be applied.

8. RF OUTPUT CONNECTOR

The "RF Out" connector is a type N connector at which the RF output signal is obtained.

3.4 REAR PANEL DESCRIPTION

Rear panel connectors are shown in Figure 3-2. Each numbered feature is briefly described in the following paragraph with the same number.

1. INTERNAL REFERENCE OUT CONNECTOR

This is the connector at which the 10 MHz sine wave internal reference signal may be obtained.

2. EXTERNAL REFERENCE IN CONNECTOR

This is the connector at which an external 10 MHz signal (TTL compatible, sign or square wave) is applied.

3. GPIB CONNECTOR

This is the connector for GPIB communication. It permits instrument operation from a remote controller (GPIB documentation is in Section 6 of this manual).

4. FAN

The fan removes instrument heat. Air inlet vents are located on the bottom cover near the front of the unit.

5. AC POWER CONNECTOR MODULE

The voltage selector in this module is removable. It must be inserted in the correct AC line voltage position to adjusts the unit's power supply correctly. (See Section 2.4 and Figure 2-1 of this manual for greater detail.)

6. OPTION PLUGS

These four (4) plugs cover openings for installation of options. Options may be installed at the factory when a unit is ordered or in the field by the customer.

7. WARNING LABELS

The electrical shock and fuse replacement warnings are on the rear panel. Note that there are no user serviceable parts inside this unit. Service must be performed by qualified personnel.

3.5 LOCAL MODE OF OPERATION

In the local mode of operation the instrument is completely controlled from the front panel. Front panel control involves interaction of the display, function keys, and termination keys.

3.5.1 TURN ON

Depress the power switch to turn on the unit. The unit will power up with the RF output off. The front panel settings that were active when the unit was last turned off will be active when the unit is turned on again. The power up test sequence described in Section 5.5 will be performed each time power is applied to the unit. See section 5.5 for the displays associated with power up.

3.5.2 NUMERIC ENTRIES (KEYBOARD AND CURSOR KEYS)

The following front panel operations require numeric entry made using the keyboard and/or the cursor arrow keys:

- Setting the output frequency (FREQ)
- Setting the output level (LVL)
- Setting the source and type of modulation (INT AM, INT FM, EXT AM, EXT FM), and its value (% AM or kHz Deviation FM)
- Setting deviation meter (option) frequency

KEYBOARD/CURSOR KEY OPERATIONS

The keyboard/cursor key sequence and the instrument response for a numeric entry are:

a. Press the function key (FREQ, LVL, INT AM, INT FM, EXT AM, EXT FM). After the function is selected, the resolution digit for the cursor keys will be indicated on the appropriate display field for the function selected.

b. If the arrow cursor keys (See CURSOR KEY OPERATION, the next section) are to be used to determine the numeric value for the selected function, they must be used before the numeric keypad (numbers 0-9, decimal point, and +/- key) is used to enter a number.

c. Either use the cursor keys to establish the numeric value to be entered or use the numeric keypad to enter the value for the function. The first keypad number entry will appear in the most significant digit (MSD) of the display for the selected function. The cursor will appear under the digit immediately following the MSD. Blank spaces will appear in the remaining digit locations and the decimal point will not appear in the display field. Any suffix will be blanked out.

d. Enter the numbers to the left of the decimal point (see e, below). As further numbers are entered, they will be placed to the right of the previously entered digit until the last digit position has been reached. When the last position has been reached, further number entries may be accepted (up to a maximum of fifteen significant places), but will not be displayed.

e. Enter the decimal, as required. When the decimal key is depressed, the decimal point will be placed to the right of the previously entered digit. The decimal point key can be pressed more than once during a single entry, moving the location of the decimal point. Enter the remaining digits.

f. After the complete number has been entered, enter a terminator. When the correct terminator key has been pressed, the entered number will be adjusted as required to put it into the standard format. If an insufficient number of digits have been entered, for example, then the display will be filled with zeroes and these will be used for the data entry. The correct suffix will also be enabled. The function will be executed with the new data.

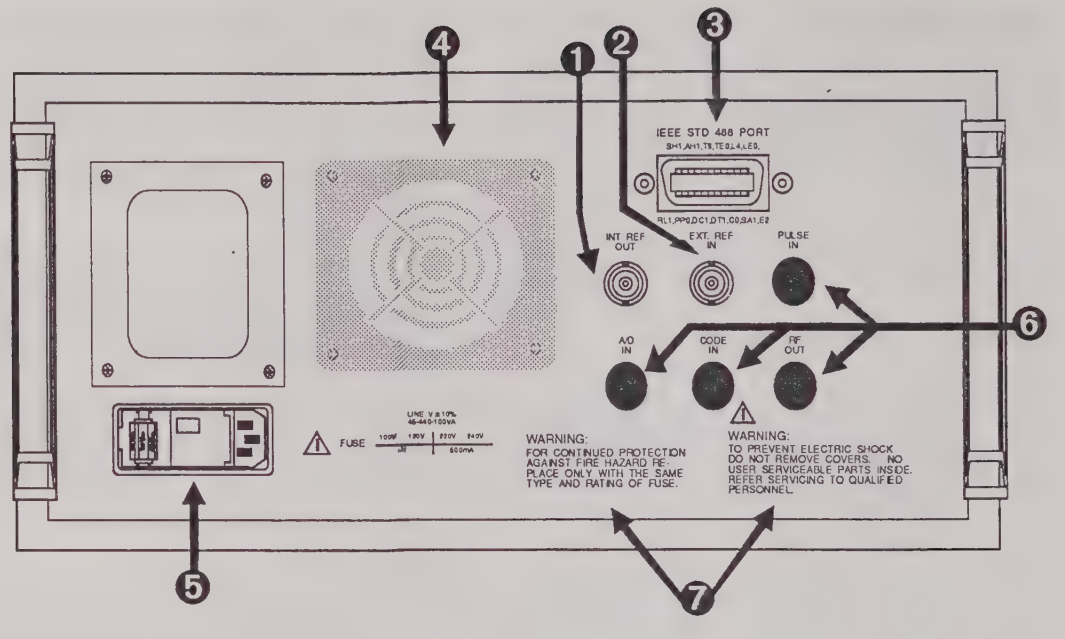


Figure 3-2. Model 2405/2410A Rear Panel

g. The following responses will occur for illegal key entries:

- Inadvertently pressing another function key during a numeric entry will enable that function. The function for which the numeric entry was being made will be restored to its previous value.

- If a non-numeric function key (discussed in Section 3.5.4) is depressed, the function will be executed without affecting the numeric entry process. After the non-numeric process has been executed, the numeric entry process can be completed.

- If the entered data is out of the range of the function, the previous function value will be restored and displayed.

CURSOR KEY OPERATION

The up and down arrow and left and right arrow cursor keys are used to increase or decrease the numeric value of a function. Pressing the up arrow cursor key increases the value; pressing the down arrow key decreases the value. Values for output frequency, power level, internal and external amplitude modulation, and internal and external frequency modulation may be controlled.

a. The left and right arrow cursor controls are used to select a given digit, the resolution digit, on the chosen function's display field. The resolution digit for a particular function can be changed by using the left and right arrow cursor keys. The line under the resolution digit will be moved to the left or right to indicate the selected digit. When the LSD (Least significant digit) is reached using the right arrow key, the next depression of the right arrow key will be ignored. Likewise, when the MSD (Most significant digit) is reached using the left arrow key, the next depression of the left arrow key will be ignored. No wrap-around occurs in either ""direction." The resolution digit selected for each function will be retained during operation of the 2405/2410 Signal Generator.

b. When the up/down arrow keys are pressed, the value for the selected resolution digit will increase or decrease. The digits to the left of the resolution digit will be affected by either a carry or a borrow operation and will also increase or decrease, respectively. The digits to the right of the resolution digit will not be affected by cursor key operation. These digits will maintain their previous values during cursor key operation.

The cursor keys permit very coarse control when used with the most significant digit, and very fine control when used with the least significant digit. When the upper or lower range limit of a function is reached, the display and the function parameter will stop at that value. Once the limit is reached, further use of the cursor key will not cause a further change in the displayed value.

c. **CAUTION:** When the cursor keys are used to set the output level, care should be exercised not to overdrive a device being tested.

3.5.3 NUMERIC ENTRY (KEYBOARD ONLY)

The 2405/2410 contains twenty (20) locations in memory for storage of 20 different sets of front panel settings. These locations are identified by a two digit number (00-19). The function keys ""Str" and ""Rcl" (items 13 and 14 of Figure 3-1) are used to initiate storage or recall, respectively, of the front panel settings at a given location. The numeric keyboard is used to specify the two digit location. Refer to Section 3.5.6 for a detailed discussion of the STORED SETTINGS feature.

3.5.4 NON-NUMERIC ENTRY

Six functions do not require a numeric entry. These functions are direct action functions. The desired operation will be executed when the key is depressed. The functions are:

- Selection between 400 and 1000 Hz internal modulation source (Rate) - If VAR option not installed.
- Selection of the CW unmodulated output (Mod Off)
- Local mode selection (Lcl)
- Switching the RF output on and off (RF on/off)
- Pulse mod on/off (Pulse) - if option installed
- Status key operations (Stat)

Toggle switches control the 400/1000 Hz Rate and RF on/off functions. When either key is depressed, its function toggles between the two possibilities shown.

The "Mod Off", "Lcl", and "Stat" keys select particular functions. When one of these keys is depressed, the function is executed and the appropriate annunciators are displayed. The "Stat" key is a multifunction key (see Section 3.6 for a detailed description).

3.5.5 SETTING RF OUTPUT CHARACTERISTICS (FREQUENCY, LEVEL, MODULATION)

The three basic RF output characteristics are frequency, level, and modulation. Each can be set from the front panel. This section describes the procedures to set each characteristic when the unit is in the Local Mode of operation. Remote Mode (GPIB) operation is described in Section 6. Note that all numeric entries exceeding the resolution of the selected parameter are rounded to the nearest value within resolution.

FREQUENCY

The output RF frequency of the 2405/2410 is set using the keyboard/cursor key sequence described in Section 3.5.2.

Press the "Freq" function key to initiate a change in frequency. Then enter the numeric value using the keyboard or cursor keys as described in Section 3.5.2.

The "kHz" and "MHz" keys are terminators for numeric entry of frequency. Output frequency is shown on the frequency field of the display.

When FM (Frequency Modulation) is selected and a frequency change ≥10 kHz is to be made, the 2405/2410 will be momentarily set to the CW mode. After the frequency change has been made and the generator has stabilized, the original FM output will be restored. (A frequency change <10 kHz will not turn off the modulation.)

POWER LEVEL

The RF output power level of the 2405/2410 is set using the keyboard/cursor key sequence described in Section 3.5.2.

Press the "Lvl" function key to initiate a change in output level. Enter the numeric value for the required output using the keyboard or cursor keys (Section 3.5.2). Terminate the entry using the "dBm", "dBmV", "mV", or "μV" key. Output level will be shown on the Level field of the display.

Convert dBm to mV or μV by pressing the "Lvl" function key, then pressing the "mV" or "μV"" key. The conversion from mV or μV to dBm is performed by pressing the "Lvl" key followed by pressing the "dBm" key.

CAUTION: When the cursor keys are used to set the output level, be careful not to overdrive a device being tested.

MODULATION

The "Mod Off" key selects a CW (unmodulated) output of frequency and level as set in Section 3.5.5.
Modulation of the 2405/2410 RF output signal is set using the keyboard/cursor key sequence described in Section 3.5.2.

There are three basic modes of modulation that may be selected using the function keys. They are:

- AM, Internal or External
- FM, Internal or External
- Complex, AM and FM together

Single modulation (AM, internal or external; or FM,

internal or external) is established by pressing the function key associated with the desired type of modulation ("Int AM" or "Ext AM"; "Int FM" or "Ext FM"). The numeric value for the modulation depth (AM) or deviation (FM) is then set using the keyboard/cursor key sequence (described in Section 3.5.2). Single modulation is executed by pressing the appropriate terminator key ("%" for AM; "kHz" for FM).

Section 1.2.7.1 of this manual lists the Model 2405/2410 specified AM range. Although the unit may be set to an AM depth of 100%, an AM depth greater than 90% is outside the specified range.

Section 1.2.7.2 lists the Model 2405/2410 specified deviation range for FM operation. FM has a maximum deviation range of 1 MHz over the majority of the instrument's frequency range (3-<137.4999999 MHz and >275 MHz). From 137.5 - 275 MHz, maximum FM deviation is limited to 500 kHz. If FM is set to a value greater than 500 kHz in the carrier frequency ranges valid for 1 MHz deviation, and then the carrier frequency is changed into the (137.5 - 275 MHz range valid only for 500 kHz maximum, the FM value will automatically be limited to 500 kHz. This is true for both internal and external FM whether AM is enabled or not. If AM and FM are enabled and AM occupies the upper display line, when the FM range is corrected, it will be moved to the upper display line so that the autorange limiting is noticeable.

An FM deviation greater than 10 kHz in the frequency range from 0.1 MHz to 1 MHz, for example, is outside the specified range. AM or FM operation outside specified ranges may produce one or more of the front panel messages described in Sections 3.6 and 3.7.

The following combinations of complex modulation are possible:

- INT AM and EXT FM
- INT FM and EXT AM

The order in which internal and external modulation is entered is not important. Modulation characteristics will be shown on lines 1 and 2 of the display.

Use the "Rate" function key (item 6 on Figure 3-1) to choose between internal modulation sources of 400 and 1000 Hz.

To obtain a calibrated output, an external modulating signal of 1 volt peak-to-peak (0.353 RMS) into a 600 W load must be provided.

NOTE

If the external modulating signal is not 1 volt peak-to-peak, the output will not be calibrated.

3.5.6 STORAGE/RECALL OF FRONT PANEL SETTINGS

There are 20 memory locations set aside for storage of 20 complete front panel settings (output frequency, level, and modulation settings). The function keys associated with this dedicated memory are the "Str" (store) and "Rcl" (recall) keys. Each is described below.

TO STORE A SETTING

1) Press the "Str" function key. The word "STORE" will appear on the display. The last location into which front panel settings were stored also will be displayed.

2) Enter the two digit number that designates the storage location. Location 3 would be entered as "0" and "3". The "0" is placed in the most significant digit position. The "3" will go into the least significant position.

3) When the final location digit is entered, the current front panel settings are stored at that location.

TO RECALL A STORED SETTING:

1) Press the "Rcl" function key. The word "RECALL" will appear on the display. The last location from which front panel settings were recalled will be indicated on the display.

2) Enter the two digit number identifying the location from which recall is to be performed. After entry of the second digit the display will show the two digit location entered. The front panel settings that were recalled will be executed and the display will be updated to show the recalled settings.

c. The recall function also enables the increment/decrement (up/down arrow) keys. These keys may be used to step through the stored settings. Those locations that contain invalid data (for example, a store to that location has never taken place or the data has been corrupted because of a hardware error) will be skipped. Wraparound will occur from 00 to the last stored setting location (15 or 99 depending on the option selection). If none of the stored setting locations contain valid data, the display will be nonfunctional. If a digit key entry is made, the inc/dec keys will be locked out until a second digit key entry is made.

d. The following responses will occur for illegal key entries:

1) If a terminator, sign, or decimal point key is de pressed, the key will be ignored.
2) If any function key is pressed, that function is enabled and the store/recall process is aborted. The store/recall display will be blank.

3) If the stored setting number is out of range, the entry is ignored. The display returns to the last storage location that was stored or recalled.

3.5.7 RETURN TO LOCAL MODE OF OPERATION FROM REMOTE

The "Lcl" key will cause the 2405/2410 to exit the Remote Mode (GPIB) of operation and return to full front panel operation (Local Mode). The front panel display will show the message "LOCAL" on the second line.

When the unit is in the Remote Mode, the REMOTE indicator is shown on the display. The front panel keys, except for the ""Lcl" key, are disabled. The ""Lcl" key is disabled if the local lockout command is received over the GPIB. (GPIB operation is described in Section 6 of this manual.)

3.6 STATUS KEY OPERATION

Pressing the status key (Stat) is the initial step in calling up error reporting, diagnostics, option review/programming, calibration, and control switch setting menus. Menu selections are numeric. Each number shown has an associated operation. Entering a number on the keyboard generates the operation shown on the menu. The cursor is automatically placed under the most frequent choice on each menu, allowing the selection of that choice by pressing the status key. The "+/-" key is the exit key for each menu.

3.6.1 INSTRUMENT ERROR MESSAGES

Several error messages are displayed by this instrument. An instrument malfunction or operation of the instrument outside its specified range may generate the error message sequence described in the following sections.

If an instrument error occurs, a STATUS annunciator will blink on and off in the fourth field on the second line of the normal operating display. The STATUS error message will continue to blink on and off until the "Stat" key (item 2 of Figure 3-1; section 3.3) is pressed. If a new error occurs after the initial response, the STATUS indication will begin blinking again.

After the status key is pressed to acknowledge the STATUS request, the second display line will show the following message:

1:ERROR 2:DIAG 3:OPTN 4:CAL 5:SET +:EXIT

This menu shows the available status key operations. When the "Stat" key is pressed in response to an error indication (STATUS blinking on/off), the cursor is initially located under the "E" in "ERROR" as shown above. When ERROR is implemented (press the "Stat" key when the cursor is under the "E" in "ERROR" or press the "1" key), the second line of the display will show the error condition(s) actually present. The various error indicators are:

CONTROL µP COMMUNICATION FAILURE +:Exit

or a series of up to 4 of the following errors followed by the +:Exit indicator: UNLOCK1, UNLOCK2, UNLOCK3, UNLEVEL, TRIP, MODFREQ

Individual errors are described briefly in sections 3.6.1.1 through 3.6.1.5 and in detail in Section 8. The cursor will be present under the "EXIT" message. Pressing the "+/-" key or the "Stat" key will restore the normal operating display. If the error condition is still present after returning to the normal display, the "STATUS" indicator will be on but will not be blinking. If a new error condition occurs, the STATUS indicator will begin to blink on/off again. If the error condition should disappear, the STATUS message will turn off. This operation is slightly altered if the pulse mod option is installed. Refer to Section 3.3 part 6 describing the STATUS field of the LCD for more detail.

Error reporting will not interfere with the normal operation of the unit.

If the error procedure has been implemented when no errors are in effect, the second line of the display will show:

SYSTEM OPERATIONAL + : Exit
Pressing the "+/-" key or the status key will restore the normal operating display to the LCD.

The MODFREQ (Modulation Frequency) error message indicates a problem with the selected reference. If the internal reference has been selected (Reference Programming, section 3.6.5), the MFREQ error message indicates that the internal modulation reference (400 Hz or 1000 Hz) derived from the frequency reference is not accurate. If the external reference has been selected, the MFREQ error message indicates either there is no external reference input or the input is not within specifications. This error will occur only if an

internal modulation source (AM or FM) is enabled because the modulation reference source is turned off otherwise.

A "TRIP" message on the display indicates an external input has been connected to the 2405/2410 RF output, tripping the RF circuit breaker that provides reverse power protection. If this occurs, remove the external input and then push the "RF on/off" switch, first off then on, to reset the circuit breaker.

The "UNLOCK1/UNLOCK2/UNLOCK3" messages on the display may indicate one of the phase locked loops (PLLs) in the output frequency generating circuitry has become unlocked. UNLOCK1 indicates the loop in the RF Synthesizer circuitry may be unlocked. UNLOCK2 indicates the loop in the LO (Local Oscillator) circuitry may be unlocked. UNLOCK3 indicates the loop in the reference synthesizer circuitry may be unlocked. If any of the UNLOCK messages occur, perform the calibration described in Section 5.4 of this manual. (If this procedure does not erase the UNLOCK indicator, the unit has a problem that will require troubleshooting. Wavetek recommends returning the unit to the factory for repair, after factory authorization, unless the customer has highly qualified maintenance personnel that are experienced at RF repair work.)

The UNLEVEL message indicates the output amplifier/ leveling circuitry may be out of calibration. Perform the calibration described in Section 5.4 of this manual. (If this procedure does not erase the UNLEV message, the unit has a problem that will require troubleshooting. Wavetek recommends returning the unit to the factory for repair, after factory authorization, unless the customer has highly qualified maintenance personnel that are experienced at RF repair work.)

The "CONTROL µP COMMUNICATION FAILURE" message on the display indicates the control microprocessor communication system has failed during execution of a command. This failure can be due to a component failure of the dual-port RAM or failure of the control microprocessor or any of its associated memory and decoding.

3.6.2 DIAGNOSTIC PROCEDURES

Pressing the status key ("Stat") during normal operation will call up the initial screen for status key operations. The first line will contain normal operating information The second line will look like: 1:ERROR 2:DIAG 3:OPTN 4:CAL 5:SET +:EXIT

To initiate the Diagnostics, press the "2" key. The diagnostic selection display will be called up:

DIAGNOSTIC
1:AUTO 2:LCD 3:KEY 4:DACS 5:DEBUG +:EXIT

Diagnostics are part of 2405/2410 maintenance and are detailed in section 5.3.

3.6.3 OPTION REVIEW AND PROGRAMMING

The option menus allow review or programming of the options installed in a unit. Press the ""Stat" key from any normal operating menu to call up the status key operation select menu (second display line shown):
1:ERROR 2:DIAG 3:OPTN 4:CAL 5:SET +:EXIT

Enter a "3" to implement Option Review or Option Programming. The initial option display called up offers the alternatives to review or program the status of options installed or to be installed in the unit:

OPTION PROGRAMMING
1:REVIEW 2:PROGRAM +:EXIT

To review the options currently installed, enter a "1" from the initial option review/programming menu. The options installed will be shown in a series of displays that follow the format:

OPTION REVIEW <BACK>:NEXT
(—option header—) (sel) +:EXIT

The name of the option currently being considered will be displayed where "(—option header—)" is shown. The current setting of that option will be displayed where "(sel)" is shown. Option header messages and their associated selection choices are shown as follows:

Header	Sel1	Sel2	Sel3
SUFFIX KEY OPERATION	dBmV	dBµV	-
STORED SETTINGS	20	100	-
FREQUENCY DOUBLER	OFF	ON	-
VARIABLE MOD RATE	OFF	ON	-
EXT PULSE MODULATION	OFF	ON	-
INT PULSE MODULATION	OFF	ON	-

Header	Sel1	Sel2	Sel3
EXTENDED POWER	OFF	ON	-
EXTERNAL PHASE MOD	OFF	20rad	50rad
LOW FREQ EXTENSION	OFF	ON	-
SELECTABLE MID RATE	400 Hz	150 Hz	-

The cursor forward and backward keys (left and right arrow keys) are used to scroll through the series of option review menus. When at the first option selection,

the left arrow key will not function. When at the last option selection, the right arrow key will not function. Pressing the + key will always exit to the previous menu selection.

To program options, enter a "2" from the initial option review/programming menu to call up the following screen:

```
OPTION PROGRAMMING:                + :EXIT
ENTER SECURITY CODE:
```

At this point the security code (password) for option programming must be entered. The security code is supplied separate to this manual for security reasons. When the security code is entered correctly, the display will show a series of screens that list the options that can be programmed:

```
(—option header—)                  <BACK>:NEXT
      1.sel1  2.sel2                    +:EXIT
```

The name of the option being considered will be in the "(—option header—)" location. The selections available for that option will be displayed where "sel1" and "sel2"' are shown. An asterisk (*) will be substituted for the number of the selection that is currently programmed. To change an option, press the number of the desired selection. The asterisk will replace that number to indicate the selection has been made. Option header messages and their associated selection choices are shown earlier in this section. Only the SUFFIX KEY OPERATION option is programmable through the front panel. All other options are automatically set on powerup when the options are installed. The cursor left and right arrow keys are used to step through the series of options. Pressing the + key will recall the previous menu selection.

3.6.4 Calibration

Pressing the "Stat" key during normal operation will call up the initial screen for status key operations (second display line shown):

```
1:ERROR 2:DIAG 3:OPTN 4:CAL 5:SET +:EXIT
```

To initiate calibration procedures, press the "4" key. Calibration is part of 2405/2410 maintenance. Calibration is described in detail in section 5.4 of this manual.

3.6.5 Control Switch Setting

The Control Switches set the reference source (internal or external), load the factory default settings into system memory, set LCD contrast, set the GPIB address and terminator, and initiate a service request. Press the "Stat" key during normal operation to call up the initial status key operations screen (second line shown):

```
1:ERROR 2:DIAG 3:OPTN 4:CAL 5:SET +:EXIT
```

Press the "5" key to call up the first of the Control Switch Set menus:

```
1:IREF10 3:STEP  4:DEFAULT  5:CNTRST
6:ADDR  7:TERM  8:SRQ        +:Exit
```

Reference Programming

In the initial control switch setting menu, shown immediately above, the "IREF10" indicates the 10 MHz internal reference is the current reference source. Enter a "1" from this menu to change from the internal reference to an external 10 MHz reference. When an external source is used, the instrument must be told an external source is being used. The following menu will be displayed if the external reference is selected:

```
1:XREF10  3:STEP  4:DEFAULT
5:CNTRST  6:ADDR  7:TERM  8:SRQ  +:Exit
```

Step parameter selection

Enter a "3" from the initial control switch setting menu to enable/disable or set the value of the step parameter. The following menu will be displayed:

```
FREQ STEP  1.0000000 MHz
   OFF                          +:Exit
```

The cursor keys (left, right, up, down) may be used to set the size of the step (numeric keys are not accepted in this mode). The range of the step parameter is the same as the range for the frequency it controls: .01 - 1100 MHz. To enable/disable the step mode, press the RF on/off key. The new status will be displayed below the "FREQ STEP" label on the lower left side of the display. To exit this mode, press either the "+/-" or "STATUS" keys.

When the STATUS menu is exited and the unit returns to the normal operating mode, the type of cursor displayed in the frequency window will indicate to the user whether the step mode is enabled or not. If enabled, the cursor is positioned over the "M" on the "MHz" suffix display and the "M" character blinks off and on. Cursoring left and right has no effect in the step mode, and coursing up and down increments/decrements the frequency value by the size of the step parameter.

Load Factory Default Settings

Enter a "4" from the initial control switch setting menu to load the factory default settings into the current settings locations in the continuously powered RAM. Calibration values are not affected. An asterisk will be placed in front of the DEFAULT characters to indicate the operation is complete:

1:IREF10 3:STEP *:DEFAULT
5:CNTRST 6:ADDR 7:TERM 8:SRQ +:Exit

The default conditions are shown in following table.

MOD	**OFF**
FREQ	1 MHz
LEVEL	0 dBm
INT AM	0%
EXT AM	0%
INT FM	0 kHz
EXT FM	0 kHz
RF	**OFF**
INT MOD RATE	1 kHz
MOD	OFF
FREQ STEP	1 MHz
FREQ STEP	DISABLED
IPM duty cycle	50% (opt)

LCD CONTRAST

Enter a "5" from the initial control switch setting menu to call up the LCD contrast adjustment screen:

DISPLAY CONTRAST PROGRAMMING***** 0
Adjust using up/down arrows +:EXIT

LCD contrast can be adjusted using the up and down arrow cursor keys, as indicated by the directions shown on the second line of the LCD. The contrast level is displayed on the right side of the upper display line. There are 16 levels of contrast, from a minimum "0" level to a maximum "15" level. To leave this procedure, press the "+/-" key or the status key.

GPIB ADDRESS

Entry of a "6" from the initial control switch setting menu calls up the GPIB address setting screen:

GPIB ADDRESS SELECTION: 02
ENTER NEW SELECTION (00T030):** +:EXIT

The GPIB address can be programmed for any value from 00 to 30. The value for the current address is shown on the first line of the display. The second line shows the address range and has asterisks where the new address should be entered. The two asterisks indicate that two digits of programming are required. The up/down cursor keys may be used to step through the selections, or the 2-digit numeric value may be entered directly. Pressing the "+/-" key or the status key will immediately activate the new address. If no new address is entered, the current address displayed will be maintained. The factory default address is 02.
GPIB terminator

Entering a "7" from the initial control switch setting menu calls up the GPIB terminator programming menu:

GPIB TERMINATOR SELECTION:
10 LF ENTER NEW SELECTION (00T031):** +:EXIT

Any ASCII characters corresponding to a decimal number from 00 to 31 may be used as a GPIB terminator. The terminators LF, EOI, and CR are always accepted as GPIB input terminators, regardless of the terminator chosen using this display menu. This menu provides an additional input terminator, a fourth acceptable terminator. The first line of the display identifies the procedure and indicates the terminator currently chosen in hexadecimal value and its ASCII mnemonic to the right of it. The second line shows available terminator range and has asterisks to indicate the two digit decimal value to enter to select a different terminator.

The ASCII characters associated with any number from 00 to 31 may be used. The most common terminator/ ASCII numbers are:

NUL	(Null Character)	00
LF	(line feed)	10
CR	(Carriage Return)	13

The EOI (End or Identify) terminator is always an output terminator, regardless of the terminator chosen using this display menu. The terminator chosen using this display menu will also be sent as an output terminator. The factory default terminator is LF, because it is specified in IEEE 488.2 and it is the most commonly used terminator. The up/down cursor keys may be used to step through the selections, or the 2-digit numeric value may be entered directly. Terminator programming is executed immediately upon pressing the "+/-" key or the status key.

SRQ OPERATION

Entering an "8" from the initial control switch setting menu will issue a service request to the GPIB. An asterisk will be placed in front of the SRQ characters to indicate the operation has been completed.

1:IREF10 3:STEP 4:DEFAULT
5:CNTRST 6:ADDR 7:TERM *:SRQ +:Exit

SECTION 4
PERFORMANCE TESTS

4.1 INTRODUCTION

This section contains the performance tests to verify that the Wavetek Model 2405/2410A RF Signal Generator meets its published specifications (Section 1.2). These tests will be performed with the unit in the Local Mode of operation as opposed to the remote (GPIB) mode.

Individual performance tests consist of the specification to be verified, the test method, test equipment required, and a detailed test procedure.

Perform the AutoCal® procedure of Section 5 if a performance test cannot be completed satisfactorily, then repeat the test. If the test is failed again, after autocalibration, the factory calibration and/or troubleshooting must be performed.

The user may elect to return the unit to the factory for factory recalibration and/or repair, after authorization. The Customer Service Department at the factory is available for consultation during the regular work week.

Recommended test equipment is listed in Table 4-1. Test equipment required for each procedure is identified by number(s) from Table 4-1.

The Model 2405/2410A Signal Generator should have its top cover installed for the performance tests. All tests can be performed without access to the internal controls. See Section 2 for details of electrical installation before applying power to the unit. Throughout the tests, maintain the line voltage as specified in Section 2.4.

The results of completed performance tests should be filed for future reference. Record the performance of the signal generator to maintain a permanent record for incoming inspection, and to use as a guide for routine performance testing.

TABLE 4-1. RECOMMENDED TEST EQUIPMENT

INSTRUMENT	RECOMMENDED
(1) Signal Generator	Wavetek Model 2410AA or equivalent
(2) Oscilloscope	Tektronix 465 or equivalent, with matched X10 probes
(3) Frequency Counter	Hewlett-Packard Model 5350B with external reference time base accuracy of ± 5 parts in 10^8, or equivalent
(4) DVM	Fluke Model 8010A, or equivalent
(5) Spectrum Analyzer	Tektronix 496, 492, or equivalent H-P 8559A, or equivalent
(6) Spectrum Analyzer	Hewlett-Packard 8568, or equivalent
(7) Measuring Receiver	H-P 8902A, with sensor module 11722A, or equivalent
(8) Power Meter	H-P 436A, with Power Sensor 8482A, or equivalent
(9) Function Generator	Wavetek Model 20 or equivalent
(10) Audio Analyzer	H-P 8903A, or equivalent
(11) VSWR Bridge	Wiltron Model 60N50, or equivalent
(12) Sweep Generator	Wavetek Model 2002A, or equivalent

4.2 FREQUENCY RESOLUTION AND RANGE TEST

SPECIFICATION

MIN FREQ	MAX FREQ	RESOLUTION
.01 MHz	1100 MHz	.1 Hz

METHOD

A frequency counter is used to measure frequency resolution and range. The 2405/2410A cursor keys (see Section 3.5.2) are used to step through the frequency range to verify cursor operation. Frequency resolution may be varied from .1 Hz to 100 MHz, depending upon which digit is established as the resolution digit.

EQUIPMENT

(3)

PROCEDURE

1. Put the unit into the Local Mode of operation. Connect the Model 2405/2410A front-panel RF OUT connector to the appropriate input of the frequency counter. Use the MOD OFF key to select a CW output. Turn on the RF output.

2. Use the cursor keys to step through each frequency range shown in the following table. The underlined digit in each range is the resolution digit for that range. The value of the resolution digit will be increased one step (one unit) at a time until the entire range is verified. The Model 2405/2410A resolution per step in each range is indicated

below. Read the frequency counter after each step change. Verify the counter shows the same frequency as that set on the Model 2405/2410A, to within the specified accuracies of the counter and the 2405/2410A. Record the frequency counter values for minimum (.01 MHz) and maximum (1100 MHz) frequencies.

FREQUENCY RANGES (MHz)		2405/2410A RESOLUTION
*.0100000 -	.0100010	.1 Hz
.0100010 -	.0100100	1 Hz
.0100100 -	.0101000	10 Hz
.0101000 -	.0110000	100 Hz
.0110000 -	.0200000	1 kHz
.0200000 -	.1000000	10 kHz
.1000000 -	1.0000000	100 kHz
1.0000000 -	10.0000000	1 MHz
10.0000000 -	100.0000000	10 MHz
100.0000000 -	1100.0000000	100 MHz

** FREQUENCY COUNTER READINGS ON THE .1 HZ DIGIT MAY APPEAR UNSTABLE DUE TO RESIDUAL FM.*

4.3 FREQUENCY ACCURACY TEST

SPECIFICATION

All modes (CW, AM, FM): ± 2.5 ppm

METHOD

Set the 2405/2410A CW output to 100 MHz. Use the frequency counter to verify that the output is between 99.99975 and 100.00025 MHz. With the output frequency set for 200 MHz check for an output frequency between 199.9995 and 200.0005 MHz. With the output frequency set for 750 MHz check for an output frequency between 749.998125 and 750.001875 MHz.

4.4 HARMONICS TEST

SPECIFICATION

< -30 dBc for frequencies >10 MHz
< -26 dBc for frequencies <10 MHz

METHOD

A spectrum analyzer is used to determine levels for the second and third harmonics associated with the output frequency range of the Model 2405/2410A.

EQUIPMENT

(5)

PROCEDURE

1. Set the 2405/2410A output for .01 MHz frequency at a +13 dBm level.

2. Connect the spectrum analyzer. Use the cursor keys (see Section 3.5.2, if necessary) to establish the 10 kHz digit (0.01000) as the resolution digit and then increase the frequency from .01 MHz to 100 MHz in 100 kHz steps. Monitor the second and third harmonics on the analyzer at each step. Record the worst case. It should be less than -26 dBc.

3. Set the resolution digit at 1 MHz (10.00000 MHz) and increase the output frequency from 10 MHz to 1100 MHz in 10 MHz steps. Monitor the second and third harmonics at each step. Record the worst case. It should be less than -30 dBc.

4. Set the 2405/2410A output level at +3 dBm and repeat steps #2 and #3, described above.

5. Set the 2405/2410A output level at -3 dBm and repeat steps #2 and #3, described above.

4.5 SUBHARMONICS TEST

SPECIFICATION

-25 dBc for frequencies > 550 MHz. (2410A only)

METHOD

A spectrum analyzer is used to measure subharmonics at +13 and -3 dBm output levels in the frequency range from 551 to 1100 MHz.

EQUIPMENT

(5)

PROCEDURE

1. Set the 2410A at a 551 MHz output frequency (fo = 551 MHz) and a +13 dBm power level. Use the spectrum analyzer to check subharmonic levels at 1/2 the carrier frequency (1/2 fo = 275.5 MHz) and 3/2 the carrier frequency (3/2 fo = 826.5 MHz). Record the subharmonic levels.

2. Increase the 2410A output frequency to 1100 MHz, carefully monitoring 1/2 fo and 3/2 fo as the output frequency increases. The subharmonic frequencies in MHz for each 30 MHz value from 560 MHz are shown below.

fo	1/2 fo	3/2 fo
560	280	840
590	295	885
620	310	930
650	340	930
680	355	1020
710	355	1065
740	370	1110
770	385	---
800	400	---
830	415	---
860	430	---
890	445	---
920	460	---
950	475	---
980	490	---
1010	505	---
1040	520	---
1070	535	---
1100	550	---

Record the worst case subharmonics level(s) and location(s).

3. Repeat step 1, above, with the 2405/2410A output level set at -3 dBm.

4. Repeat step 2, above, with the 2405/2410A output level set at -3 dBm.

4.6 NONHARMONICS TEST

SPECIFICATION

Offset >5 kHz from carrier frequency: <-50 dBc

METHOD

A spectrum analyzer is used to measure nonharmonics at a -3 dBm output level.

EQUIPMENT

(5)

PROCEDURE

1. Set the 2405/2410A for a 50 MHz output signal at a -3 dBm level. Set the spectrum analyzer for a 50 - 1100 MHz sweep.

2. Use the cursor keys (Section 3.5.2) to increase frequency in 0.1 MHz steps from 50 MHz to 137.5 MHz. Check each step for nonharmonics. Record the location (frequency) and level for the worst case.

4.7 PHASE NOISE TEST

SPECIFICATION

< -107 dBc/Hz at 500 MHz; 10 kHz offset

METHOD

An H-P 8568 (or equivalent) spectrum analyzer is used to measure phase noise at 500 MHz.

EQUIPMENT

(6)

PROCEDURE

1. Set the 2405/2410A output to a frequency of 500 MHz and a 0 dBm level, with no modulation. Connect the H-P 8568 spectrum analyzer (or equivalent). Center the analyzer at 500 MHz.

2. Set the analyzer at the following values:
   50 kHz span
   1 kHz resolution BW
   30 Hz video BW
   0 dBm reference level

3. Press the following analyzer key sequence to reference the 2405/2410A output signal to the graticule of the analyzer CRT display:

a. "Peak search"
b. "Mkr→Ref level"
c. "Signal track"
d. "OFF"

4. Press the following analyzer key sequence to measure phase noise in a 1 Hz BW:

a. "Shift"
b. "Normal" (Marker)
c. "↑"
d. "↑" (again)

5. Read the phase noise value directly from the analyzer CRT display. It should be more than 107 dB below the reference level (shown at the top of the display).

4.8 SWITCHING TIME TEST

SPECIFICATION

200 msec

METHOD

An H-P 8568 spectrum analyzer, or equivalent, will be used to measure switching time over two frequency changes.

EQUIPMENT

(6)

PROCEDURE

1. Set the 2405/2410A for a 274.9 MHz output at a 0 dBm level, with no modulation.

2. Set the H-P 8568 spectrum analyzer at the following values, then connect the 2405/2410A:

a. 275.0 MHz center frequency
b. 0 dBm reference level
c. 300 kHz resolution BW
d. 100 kHz video BW
e. 0 Hz span
f. 1 Sec sweep time

3. The spectrum analyzer CRT display will be used to indicate switching time as the 2405/2410A changes frequency from 274.9 MHz to 275.0 MHz and back again. The frequency change must begin at the same time as an analyzer trace (sweep) begins (step 4, below). The "VIEW" key on the analyzer must be pushed before the end of the same sweep (step 5, below).

4. Use the 2405/2410A numeric keypad sequence (Section 3.5.2) to select a frequency change (press "FREQ" key), then enter a frequency value of 275.0 (press the appropriate numeric/decimal keys), and finally enter the terminator (press "MHz" key) at the beginning of a CRT sweep.

5. Push the "VIEW" key before the end of the sweep at which the 2405/2410A "MHz" terminator key was pushed (step 4). Performing step 4 and this step requires use of both hands, one for the 2405/2410A and one for the analyzer.

6. Note the transient character of the "stored" analyzer sweep. The trace should have settled (returned to reference level) in less than 2 horizontal screen divisions (200 msec).

7. Push the "clear/write" key on the spectrum analyzer to clear the stored CRT display.

8. Repeat step 4 above, except enter a 2405/2410A frequency of 274.9 MHz.

9. Repeat steps 5 - 7, above.

10. Set the 2405/2410A for a 389 MHz output. Set the analyzer at a center frequency of 389.1 MHz. (The remaining values are set as shown in steps 1 and 2, above.)

11. Repeat step 4, above, except set the 2405/2410A at a 389.1 MHz output.

12. Repeat steps 5 - 7, above.

13. Repeat step 4, above, except set the 2405/2410A at a 389 MHz output.

14. Repeat steps 5 - 7, above. Disconnect the spectrum analyzer.

4.9 AM PERFORMANCE TESTS

SPECIFICATION

AM Accuracy	± (1% + 5% of programmed setting)
Distortion	at 70% - <90% AM = < 5% at 30% - <70% AM = < 3% at <30% AM = < 1.5%
AM Bandwidth	10 Hz to 50 kHz: < 3 dB change at 50% AM

METHOD

An audio analyzer and a modulation analyzer or a measuring receiver will be used to measure AM accuracy and distortion at three modulation levels for +3 dBm and -3 dBm output levels. A function generator will then be used to help measure frequency response (AM bandwidth) over an external 10 Hz to 50 kHz modulation rate at 50% AM.

EQUIPMENT

(7), (9), and (10)

PROCEDURE

1. There are a variety of modulation analyzers and measuring receivers on the market that measure AM accuracy and distortion. Some audio analyzers also contain an audio generator. The user must modify the following procedure according to the equipment available.

2. Make the following connections, as appropriate. Connect the 2405/2410A output to the modulation analyzer. Connect the audio output of the modulation analyzer to the audio analyzer input. Connect the function generator output to the external modulation input of the 2405/2410A.

3. AM accuracy and distortion will be measured together at the modulation and power levels identified below. AM frequency response (bandwidth) will be tested later in this procedure (starting with step 15 below).

4. Set the 2405/2410A for an output frequency of 11 MHz, internal AM, and modulation at the 1 kHz rate. Set the output power level at +3 dBm. Set AM for 90%.

5. Press the ""+PK and ""-PK" control buttons on the modulation analyzer and record modulation accuracy. Calculate average accuracy as: $\frac{(+PK) + (-PK)}{2}$ and record this value. This must be within the [+/-] (1% + 5% of programmed setting) range specified (84.5 - 95.5%).

6. Press the appropriate button(s) on the audio analyzer to measure AM distortion. Record the displayed value (or record the distortion value determined using the modulation meter, if appropriate). Distortion must be less than 5%.

7. Repeat steps 5 and 6 for each of the following frequencies:

a. 137 MHz
b. 138 MHz
c. 194 MHz
d. 195 MHz
e. 274 MHz
f. 275 MHz
g. 400 MHz
h. 550 MHz
i. 551 MHz (2410A only)
j. 620 MHz (2410A only)
k. 692 MHz (2410A only)
l. 693 MHz (2410A only)
m. 780 MHz (2410A only)
n. 872 MHz (2410A only)
o. 873 MHz (2410A only)
p. 1000 MHz (2410A only)
q. 1100 MHz (2410A only)

8. Set the 2405/2410A AM level to 70% and the output frequency to 11 MHz. Repeat step 5, above. The average accuracy must be within the ± (1% + 5% of programmed setting) range specified (65.5 - 74.5%).

9. Repeat step 6, above, distortion must be less than 3%.

10. Repeat steps 8 and 9, above, for each of the frequencies listed in step 7, above.

11. Set the 2405/2410A for a 30% AM level and 11 MHz frequency output. Repeat step 5. AM accuracy must be within the ± (1% + 5% of programmed setting) range specified (27.5 - 32.5%).

12. Repeat step 6. Distortion must be less than 1.5%.

13. Repeat steps 11 and 12 for each frequency listed in step 7, above.

14. Repeat steps 4 - 13, above, with the 2405/2410A power output set at the -3 dBm level.

15. To measure frequency response (AM bandwidth) set the 2405/2410A for external AM at a 50% modulation level. Set the output frequency at 11 MHz and power at +3 dBm. Set the function generator for a 1 volt peak-to-peak signal at 1 kHz (at the ""Mod In" connector on the 2405/2410A front panel). Set the modulation meter as follows:

a. Push the AM modulation button.
b. Push the ratio button at the 1 kHz modulation rate.
c. Press the "Ave" button.

16. Use the function generator to sweep from 1 kHz to 50 kHz while observing the relative dB output change on the modulation meter. Record the change. It should be less than 3 dB.

17. Repeat steps 15 and 16 for each of the frequencies listed in step 7.

4.10 RESIDUAL AM TEST

SPECIFICATION

< -60 dBc; CW mode with 50 Hz to 15 kHz post detection bandwidth (PDBW)

METHOD

A measuring receiver is used to measure residual AM at a variety of output frequencies.

EQUIPMENT

(7)

PROCEDURE

1. Set the 2405/2410A for a 200 kHz output at the 0 dBm level with no modulation.

2. Connect the 2405/2410A output to an HP-8902A measuring receiver, or equivalent. Select the 50 Hz high pass and 15 kHz low pass post detection bandwidth filters on the measuring receiver. Put the receiver in the average detection mode.

3. Record the residual AM measurement. It should be < -60 dBc.

4. Change the 2405/2410A frequency output to each of the frequencies listed below and record the residual AM associated with each. Each should be < - 60 dBc.

a. 1 MHz
b. 2 MHz
c. 5 MHz

d. 10 MHz
e. 20 MHz
f. 50 MHz
g. 100 MHz
h. 200 MHz
i. 400 MHz
j. 800 MHz (2410A only)
k. 1100 MHz (2410A only)

4.11 RESIDUAL FM TEST

SPECIFICATION
(50 Hz to 15 kHz post detection bandwidth)

<30 Hz rms (<137.5 MHz)
<12.5 Hz rms (137.5 - 275 MHz)
<25 Hz rms (275 - 550 MHz)
<50 Hz rms (550 - 1100 MHz) (2410A only)

METHOD

A measuring receiver is used to measure residual FM at selected frequencies from 100.001 MHz to 550 MHz.

EQUIPMENT

(7)

PROCEDURE

1. Set the 2405/2410A for a 100.001 MHz output at the 0 dBm level with no modulation.

2. Connect the 2405/2410A output to an HP-8902A measuring receiver, or equivalent. Select the 50 Hz high pass and 15 kHz low pass post detection bandwidth filters on the measuring receiver. Put the receiver in the average detection mode.

3. Record the residual FM measurement. It should be less than 30 Hz rms.

4. Change the 2405/2410A frequency output to each of the frequencies listed below and record the residual FM associated with each. Each should be less than the values indicated below:

a.	128.001 MHz	30 Hz rms
b.	275 MHz	25 Hz rms
c.	325 MHz	25 Hz rms
d.	330 MHz	25 Hz rms
e.	390 MHz	25 Hz rms
f.	463 MHz	25 Hz rms
g.	464 MHz	25 Hz rms
h.	550 MHz	25 Hz rms

5. The user may elect to choose and then determine residual FM values associated with 2405/2410A frequency outputs in the .01 - 137.5 MHz range, the 137.5 - 275 MHz range, and the greater than 550 MHz range, if desired. The successful performance of steps 1 through 4, above, will automatically verify the .01 - 137.5 MHz, 137.5 - 275 MHz, and greater than 550 MHz ranges.

4.12 FM PERFORMANCE TESTS

SPECIFICATIONS

FM Accuracy	± 5% of setting, at internal rates (excluding residual FM)
Distortion	< 2% at internal rates for deviation < 100 kHz (excluding residual FM)
FM Frequency Response	From 50 Hz to 100 kHz with respect to 1 kHz reference: < 3 dB relative change
Deviation Range	For 1 kHz rate: 1 MHz peak for 3 - <137.4999999 MHz and ≥ 275 MHz 500 kHz peak for 137..5 - 274.9999999 MHz 100 kHz peak for 1 - <3 MHz 10 kHz peak for .01 - <1 MHz

METHOD

A modulation analyzer is used to measure FM accuracy. An audio analyzer and a modulation analyzer are used to measure FM distortion. A function generator and modulation analyzer are used to measure the FM bandwidth. The frequency deviation range is measured using a spectrum analyzer.

EQUIPMENT

(5), (7), (9), and (10)

PROCEDURE

1. There are a variety of modulation analyzers on the market that measure FM accuracy and distortion. Some audio analyzers also contain an audio generator. The user must modify the following procedure according to the equipment available.

2. Make the following connections, as appropriate. Connect the 2405/2410A RF output to the modulation analyzer. Connect the audio output of the modulation analyzer to the input of the audio analyzer.

3. To determine FM accuracy, set the 2405/2410A for an output frequency of 275 MHz at the 0 dBm power level. Select the internal 1 kHz modulation source. Set internal FM deviation at 99.9 kHz. Read deviation accuracy on the modulation analyzer (+PK value) and verify it is between 94.9 kHz and 104.9 kHz.

4. Repeat step 3, increasing the 2405/2410A output frequency from 275 MHz to 550 MHz in 5 MHz steps. Verify FM deviation shown on the modulation analyzer is between 94.9 kHz and 104.9 kHz at each frequency. Record the worst case deviation.

5. To further check FM accuracy and to check FM distortion, set the 2405/2410A output frequency to 500 MHz. Record the FM accuracy reading (+PK) on the modulation analyzer. It must be between 94.9 and 104.9 kHz ± (5% of setting). Set the modulation analyzer to measure FM distortion and record the value shown.

Distortion must be less than 2%.

6. Set FM deviation at 100.0 kHz. Measure FM accuracy and distortion. Accuracy as shown on the modulation analyzer must be between 95 kHz and 105 kHz. Distortion must be <2%.

7. Change the 2405/2410A internal modulation source from the 1 kHz to the 400 Hz source. Set FM deviation at 99.9 kHz. Record FM accuracy and distortion. Verify accuracy is between 94.9 kHz and 104.9 kHz and distortion is less than 2%.

8. Set FM deviation at 100.0 kHz. Record accuracy and distortion. Verify accuracy is between 95 kHz and 105 kHz. Verify distortion is less than 2%.

9. To measure FM frequency response, set the 2405/2410A for external FM at 9.9 kHz deviation. Set the output frequency at 330 MHz.

10. Use the function generator to apply a 1 Vpp signal at a 1 kHz rate to the 2405/2410A.

11. Set the modulation analyzer for "average" detection. Use the Rel dB function on the analyzer to set the modulation reference rate at 1 kHz.

12. Use the function generator to sweep from 50 Hz to 100 kHz while observing the relative dB output change on the analyzer. Record the change. It should be ± 3 dB or less.

13. Disconnect the test equipment. To measure deviation range connect the 2405/2410A RF output to a spectrum analyzer. Set the 2405/2410A at the 1 kHz internal rate source, at an FM deviation of 1000 kHz, and an output frequency of 389 MHz. Use the spectrum analyzer to verify a deviation range of 1 MHz ± 5% (2 MHz peak to peak).

14. Select an output frequency value between 137 to 275 MHz. Repeat step 13. Verify the 500 kHz peak deviation range on the spectrum analyzer.

15. Disconnect the spectrum analyzer.

4.13 OUTPUT POWER ACCURACY TEST

SPECIFICATION

± 1.5 dB

METHOD

A measuring receiver with power sensor is used to measure output power at 3 representative frequencies.

EQUIPMENT

(7)

PROCEDURE

1. Connect the 2405/2410A RF output to the power sensor for the measuring receiver. Set the 2405/2410A for an

output frequency of 5 MHz at a +13 dBm power level.
2. Read the power measurement on the measuring receiver and verify it between +14.5 and +11.5 dBm.

3. Set output power to 0 dBm and verify the measuring receiver reading is between -1.5 and +1.5 dBm.

4. Use the cursor keys to set the output power resolution digit at the 10 dB incremental position and to decrease output power in 10 dB steps. Observe the output level on the measuring receiver and verify it is within ± 1.5 dB of each output level setting below:

Output (dBm)
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120

5. Set the 2405/2410A output frequency to 400 MHz. Set the power level at +13 dBm. Repeat step 2, above.

6. Repeat step 3, above.

7. Repeat step 4, above.

8. Set the 2410A output frequency to 1100 MHz. Set the power level at +13 dBm. Repeat step 2, above.

9. Repeat step 3, above.

10. Repeat step 4, above.

11. Disconnect the test equipment.

4.14 OUTPUT POWER LEVEL FLATNESS TEST

SPECIFICATION

± 1 dB

METHOD

A power meter is used to measure the most representative output levels across the 2405/2410A frequency spectrum.

EQUIPMENT

(2) and (8)

PROCEDURE

1. Connect the power sensor unit of the power meter to the 2405/2410A RF output. Set the 2405/2410A output at the +13 dBm level.

2. Use the cursor keys (see Section 3.5.2, if necessary) to sweep through the 2405/2410A frequency spectrum (.01 MHz to 1100 MHz) while monitoring output power on the power meter. Verify the highest output power is within 2 dB of the lowest output power across the frequency range.

3. Set the 2405/2410A output level at +3 dBm. Repeat step 2.

4. Set the 2405/2410A output level at -3 dBm. Repeat step 2.

5. Disconnect the test equipment.

4.15 OUTPUT IMPEDANCE TEST

SPECIFICATION

50 W, with VSWR < 1.5:1 at output power < -3 dBm

METHOD

A VSWR bridge, spectrum analyzer, and sweep generator are used to measure output impedance across the frequency range.

EQUIPMENT

(5), (11), and (12)

PROCEDURE

1. Connect the RF input of the VSWR bridge to the sweep generator output. Connect the VSWR reference short across the bridge test port. Connect the bridge RF output port to the spectrum analyzer input.

2. Set the sweep generator to sweep from 0 - 1100 MHz using a 20 second sweep at a power level of +10 dBm. Store this data in the spectrum analyzer as the reference level.

3. Set the 2405/2410A for an output frequency of 50 MHz at a -3.1 dBm output power level.

4. Remove the reference short from the test port on the VSWR bridge and connect the 2405/2410A output to the test port.

5. Use the sweep generator to manually sweep the frequency range (.01 MHz to 1100 MHz) again. Compare these spectrum analyzer readings to the spectrum analyzer reference level from step 2. Record the worst case frequency and level. The worst case level should be < -14 dBm from the reference level.

4.16 EXTERNAL REFERENCE TEST

SPECIFICATION

External source specification

METHOD

A signal generator is used to verify the 2405/2410A external reference circuitry.

EQUIPMENT

(1)

PROCEDURE

1. Determine the error in the external source.

2. Connect the external source (a Wavetek Model 2510A signal generator, for example) to the external reference input on the rear panel of the 2405/2410A. Set the source at 1 volt peak-to-peak and 10 MHz. Set the 2405/2410A external reference selection at 10 MHz.

3. Set the output frequency for the 2405/2410A at 100 MHz and set the power level to 0 dBm.

4. Verify that the 2405/2410A output frequency is within the external source limits.

5. Disconnect the external source and set the 2405/2410A reference at the appropriate value.

SECTION 5
MAINTENANCE

5.1 INTRODUCTION

This section provides maintenance information for the Wavetek Model 2405/2410A RF Signal Generator. Maintenance consists of service information (fan/air filter maintenance and top cover removal instructions), user diagnostics, and calibration procedures. This section also contains a description of the instrument test sequence automatically performed when the power is turned on.

WARNING
High voltages are present in this unit. Do not operate this unit with the cover removed and the power on.

5.2 SERVICE INFORMATION

5.2.1 FAN/AIR FILTER MAINTENANCE

The rear-panel fan reduces operating temperature, and contributes to the long life of the instrument. The air filter installed in the bottom intake vents must be kept clean. Remove the cover and clean the air filter as described below.

5.2.2 COVER REMOVAL

The cover is U-shaped and wraps around and covers the sides of the unit. Remove power from the instrument. Lay it on its top (with the bottom up). Remove the six bottom screws. Place the unit right side up again. Remove the eight rear panel screws. Remove the two screws on top near the front of the unit. Slide the cover back and remove it. (Reverse this procedure to reinstall the cover.)

5.2.3 AIR FILTER CLEANING

The air filter is glued to the bottom cover. Use an air hose to direct a stream of air against the filter to clean it.

5.3 USER DIAGNOSTICS

The user diagnostics allow the user to verify proper operation of 2405/2410A subsystems. When the 2405/2410A is in user diagnostics, any command across the GPIB bus will be ignored.

Press the status key ("Stat") to call up the status key select menu (second line of the display shown):

1:Error 2:Diag 3:Optn 4:Cal 5:Set +:Exit

Press the "2" key to implement the diagnostics (DIAG). Software will turn off the RF output (RF OFF) and store the current instrument settings. The diagnostic selection display will be called up:

DIAGNOSTIC
1:AUTO 2:LCD 3:KEY 4:DAC'S 5:DEBUG +:EXIT

The first line indicates the instrument is in the diagnostic mode. The second line displays the available diagnostic functions. To implement a choice, press the numeric key associated with the choice. EXIT (pressing the "+/- key or STATUS key") will recall the settings that were saved when DIAGNOSTICS was implemented and will return the instrument to normal operation.

5.3.1 AUTOMATED DIAGNOSTICS

Pressing a "1" from the diagnostics select menu will initiate the sequence of diagnostic tests shown in Table 5-1.

TABLE 5-1. AUTOMATED DIAGNOSTICS

1 Control Microprocessor (internal timer)
2 Communications Microprocessor (internal timer)
3 Non-volatile RAM (Battery Backed-up RAM)
4 Dual Port RAM
5 Static RAM
6 Control ROM
7 Communication ROM
8 RF Data/Address Bus
9 Card ID Code
10 ADC/DAC
11 LO Unlocked Feedback
12 Synthesizer Unlocked Feedback
13 Carrier Unleveled Feedback
14 400 Hz Feedback

These tests are performed automatically. As it is executed, the name of the test is shown on the top line of the display. The bottom line of the display is blank. If the test passes, the next test in sequence will be executed. If the test fails, the fail message and a failure code identifying the type of failure will be displayed and auto-sequencing will halt. The test may by repeated, or the next test may be initiated, or the auto-diagnostics mode may be exited.

Display formats for test failed is:

DIAGNOSTIC ACTIVE:<diagnostic name>
FAIL XXXX 1:CONT 2:REPEAT+:EXIT

A code "XXXX" for the specific cause of the test failure and further operator choices will be indicated on the second line of the display. Failure codes are troubleshooting aids and are described in detail in Section 8.

For example, while the control microprocessor test is running, the display will look like:

DIAGNOSTIC ACTIVE:CONTROL MICROPROCESSOR

If the test passed, the next test, the COMMUNICATION MICROPROCESSOR test will begin.

If a failure results during testing, automatic testing will halt. A failure of the non-volatile RAM test might produce the following display:

DIAGNOSTIC ACTIVE:NON-VOLATILE RAM
FAIL 0000 1:CONT 2:REPEAT+:EXIT

The "0000" indicates the control microprocessor is bad. Press the "1" key to continue with the remaining tests. Press a "2" to repeat the failed test. Press the "+/-" key to exit the automatic diagnostics and recall the diagnostics select menu.

When the entire automatic test sequence is completed, the second line of the display will show a summary of test results. Successful completion of all tests will be indicated as:

DIAGNOSTIC TESTS COMPLETE:
PASSED +:EXIT

If failures occur, their number will be shown. For example:

DIAGNOSTIC TESTS COMPLETE:
FAILED IN 02 TESTS +:EXIT

The automated diagnostics are described briefly in the following sections. Diagnostics are verifications of proper operation. They also provide valuable troubleshooting information if a failure occurs. (See section 8 for a detailed description of the failure codes associated with each auto-diagnostic test).

Please note that although the 2405/2410A is simple to operate and calibrate, it is a very sophisticated instrument. To troubleshoot and repair a malfunctioning unit requires a thorough knowledge of sections 3-5 and 7-10 of this manual, and great technical expertise and experience with this type of instrument. Wavetek recommends return of a malfunctioning unit to the factory for repair (after factory authorization).

TESTS NUMBER 1-2: MICROPROCESSOR TESTS

The microprocessor tests verify proper operation of the control and communication microprocessor circuitry.

TESTS NUMBER 3-7: RAM/ROM TESTS

The RAM/ROM tests verify ROM checksums and RAM read/write integrity.

TEST NUMBER 8: RF DATA/ADDRESS BUS TEST

The RF Data/Address Bus test verifies that the RF data and address bus operates correctly.

TEST NUMBER 9: CARD ID CODE TEST

The Card ID (Identification) Code Test verifies that all cards are installed in their proper slots and that the RF address and card select bus functions properly. It does these verifications by reading the cards' ID codes.

During this test, the current hardware options are determined from the card ID codes and saved in a table. This test is also run on every powerup of the instrument.

TEST NUMBER 10: ADC/DAC TESTS

The ADC used in instrument calibration and deviation meter measurements is tested for accuracy. Three of the five DAC's are set to minimum and maximum values, and their accuracies are measured by the ADC. Also a 0v and + 10 V test is performed to verify correct operation.

TESTS NUMBER 11-14: FEEDBACK TESTS

The feedback tests check the ability to monitor the hardware error conditions associated with each entry number.

5.3.2 LCD TEST

The diagnostic select menu is:

DIAGNOSTIC
1:AUTO 2:LCD 3:KEY 4:DAC'S 5:DEBUG +:Exit

Pressing the "2" key from this menu will call up a two-line display test pattern that shows a complete set of alpha-numerics plus special symbols. All printable characters are shown. The display lasts for approximately 2 seconds, after which the diagnostic menu is redisplayed. The characters displayed are ASCII characters from hex 30 to 7F, except for a few special symbols that are unique to the LCD display. These exceptions are:

$5c - displayed as Y
$7e - displayed as →
$7f - displayed as ←

The purpose of this test is to verify that all of the character locations on the display are readable, and that the data port driving the display is wired correctly.

5.3.3 KEY TEST

The key test verifies the keyboard is functional. It tests for stuck keys and for miswired and no-contact keys. A detailed description of this test and its applications to troubleshooting is contained in section 8.

Select the key test from the diagnostic select menu:

DIAGNOSTIC
1:AUTO 2:LCD 3:KEY 4:DAC'S 5:DEBUG +:Exit
Entering a "3" will call up the key test screen.

KEY TEST: PRESS TO DISPLAY KEY +:Exit
xxxxxx

If a key is stuck, its associated label will be shown in the "xxxxxx" location on the display. Key labels shown are self explanatory. If more than one key is stuck, only one of the keys will be displayed.

When a key is pressed, the mnemonic (key label) associated with the key is shown. For example, pressing the "Mod Off" key will generate:

KEY TEST: PRESS TO DISPLAY KEY +:Exit
MOD OFF

Key labels are:

INT AM, EXT AM, INT FM, EXT FM, EXT OM, EXT PM, RATE, MOD OFF, POS MET, NEG MET, 1, 2, 3, 4, 5, 6, 7, 8, 9, 0, ., LEFT, RIGHT, RF, FREQ, LVL, STR, RCL, LCL, MHz/MV, kHz/UV, dBm/%, dBmV, UP, DOWN

If a key makes no contact, pressing it will not display a label. When checking the keys, remember to press the "+/-" key and the "STATUS" key last because these will exit to the diagnostics menu.

5.3.4 DAC'S TEST

There are two basic screens associated with the DAC'S diagnostics. The A/D Testpoint Selection screen is the first of the two basic screens. The second basic screen is the DAC Entry Selection screen. Both screens are described in the following section. The RF ON/OFF key may be used to toggle between the two screens. The DAC's diagnostics may be exited by pressing the STATUS key.

The DAC's diagnostics are selected from the diagnostic select menu:

DIAGNOSTIC
1:AUTO 2:LCD 3:KEY 4:DAC'S 5:DEBUG +:Exit

Entering a "4" from this menu will call up the A/D Testpoint screen:

ADC Test: +: Pos A/D: +x.xx v
00: Ground ref A/D value: xxx

The testpoint number (00) and its name (Ground ref) are identified. The "xxx" value displays the current A/D value being read for the selected testpoint. The "x.xx" indicates the equivalent voltage for that A/D value. The A/D readings are taken continuously at approximately a 200 msec sampling rate.

Table 5-2 lists testpoint selections by number, with a description of each testpoint.

TABLE 5-2 A/D TESTPOINT SELECTIONS

Number	Description
00	Ground ref
01	+10 V ref
02	AM DAC output
03	FM DAC output
04	Level DAC output
05	Temp sensor
06	Ext analog input
07	Syn: error voltage
08	Syn: tuning voltage
09	Dbl: loop error
10	Dbl: loop ctrl
11	AM: testpt 1
12	AM: testpt 2
13	AM: testpt 3
14	Out: detect test
15	Out: PIN test
16	Ref: VCO tuning

The key function definitions in this mode are as follows:

"+/-": Toggles between a positive and negative peak detection of the selected testpoint. The current status is displayed on the upper line following the "+:" and is indicated by "Pos" or "Neg."

"INC" (Up Arrow): Increments the testpoint selection number.

"DEC" (Down Arrow): Decrements the testpoint selection number; no effect when the selection number is "00".

"RF ON/OFF": Calls up DAC Entry Selection screen (described following A/D Testpoint screen text).

"STATUS": Exit DAC's Diagnostics and recall diagnostic select menu.

The maximum voltage that can be read by the A/D is ±10 volts. Voltages up to ± 15 volts will not cause damage but will be displayed as ± 10 volts.

Additional troubleshooting information associated with this test is located in Section 8.22.

The A/D Testpoint screen is the first of two basic screens associated with the DAC's diagnostics. Press the RF ON/OFF key to call up the second basic screen, the DAC Entry Selection screen:

DAC TEST: Pos A/D: +x.xx v
00: Ramp all DAC's +: Start

The "x.xx"indicates the A/D voltage for the last testpoint selected. The key function definitions in this mode are as follows:

"+/-": This key starts/stops the ramp DAC test. Whether the key will start or stop the ramp test is shown on the second line of the display following the "+:" entry. When this test is entered from another DAC test or the A/D Testpoint screen, the ramp test is off and the key function is "Start," as shown above. When the key is pressed, the DAC's are ramped and the function of the key becomes "Stop," which is then displayed after the "+:" on the second line of the LCD. The ramp DAC's test consists of ramping all 12-bit DAC's simultaneously. The coarse tune and loop compensation DAC's are alternately ramped, with the unramped DAC kept at a midrange value.

"INC" (Up Arrow): Increments the DAC test selection number. This key has no effect when the highest selection (11) number is active. A list of test selections is shown in Table 5-3, with a description of the test associated with each test number and the size of the register (number of bits) for the DAC.

"DEC" (Down Arrow): Decrements the test selection number; has no effect when the selection number is "00"

"RF ON/OFF": Calls up A/D Testpoint screen (described earlier in this section).

"STATUS": Exit DAC's Diagnostics and recall diagnostic select menu.

TABLE 5-3 DAC TEST SELECTIONS

NUMBER	DESCRIPTION	BITS
00	Ramp all DAC's	N/A
01	AM depth DAC	12
02	FM dev DAC (lo)	12
03	FM dev DAC (hi)	12
04	Level DAC 12	
05	Coarse tune DAC	8
06	Loop comp DAC	8
07	A aux p11 reg	8
08	N aux p11 reg	12
09	R aux p11 reg	12
10	A main p11 reg	8
11	N main p11 reg	12
12	R main p11 reg	12

The initial DAC Entry Selection screen is:

DAC Test: Pos A/D: +x.xx v
00: Ramp all DAC's +: Start

Press the "INC" (Up arrow) key to call up the screen for DAC test number 01:

DAC TEST: Pos A/D: +x.xx v
01: AM depth DAC DAC value: xxx

This is a typical screen for non-ramp DAC tests. The test selected is identified on the second line of the display. The "xxx" value displays the last DAC value written to the selected DAC (the AM depth DAC, in this case). The "x.xx" indicates the equivalent voltage for that DAC value. In all the DAC tests except the "Ramp all DAC's" test, numeric keys may be used to make DAC data entries. The data is entered in hexadecimal (base 16) code format. Code entries terminate automatically after 3 digits for the 12-bit DAC's and after 2 digits for the 8-bit DAC's and the PLL registers. The numeric keys 0-9 are used for the digit values 0-9. For the hex digit values A-F, the following keys are used:

Hex	Key
A	MHz
B	kHz
C	dBm
D	OPT
E	+/-
F	

The RIGHT and LEFT arrow keys may be used with non-ramp DAC tests:

"RIGHT" (arrow key): If the cursor is currently under the DAC test selection number, the cursor will be moved to the most significant digit of the current DAC value. If the cursor is under a digit of the current DAC value, the cursor will be positioned one digit position to the right, unless it is under the least significant digit of the current DAC value. If it is under the least significant digit of the current DAC value, it will be repositioned under the DAC test selection number.

"LEFT" (arrow key): If the cursor is currently under the DAC test selection number, the cursor will be moved to the least significant digit of the current DAC value. If the cursor is under a digit of the current DAC value, the cursor will be shifted one digit position to the left, unless it is under the most significant digit of the current DAC value. If it is under the most significant digit of the current DAC value, it will be repositioned under the DAC test selection number.

The "INC" and "DEC" (UP and DOWN arrow) keys will increment and decrement the current digit of the DAC value selected when the cursor is positioned under the DAC VALUE.

When the ramp DAC's test is performed (Test 00), the internal modulation rate selection is set for 1 kHz with both AM and FM selected (to observe the ramp output of the DAC's) and the high range FM mode is selected (for the larger ramp voltage output). One complete cycle of ramping the 12-bit DAC's requires approximately one minute. The PLL registers are not affected during the ramping. For the AM and FM DAC test selections, again the internal modulation rate selection is set for one kHz and AM and FM are enabled so that the DAC output is enabled.

When performing DAC test 01 (AM depth DAC), set the DAC value at "000" and verify the corresponding voltage shown is "0.00 V". Then set the DAC value to "FFF" and verify a voltage of "9.99V".

DAC test 02 (FM deviation DAC), should be performed at the low and high ranges of the DAC. To test the DAC's low range, first return to normal operation (leave the DAC's diagnostic mode) and set internal FM to 1 kHz. This sets the high/low FM range bit for a low range output. Return to the DAC's diagnostics. Set the DAC value at "000" and verify the corresponding voltage shown is "0.00 V". Then set the DAC value to "FFF" and verify a voltage of "1.00 V". To test the DAC's high range, return to normal operation (leave the DAC's diagnostic mode) and set internal FM to 1 MHz. This sets the high/low RM range bit for a high range output. Return to the DAC's diagnostics. Set the DAC value at "000" and verify the corresponding voltage shown is "0.00V". Then set the DAC value to "FFF" and verify a voltage of "9.99V".

To perform DAC test 03 (Level DAC), first go to DAC test 01 and set the AM depth DAC value at "000" Then return to DAC test 03 (level DAC. Set the DAC value at "000" Verify the corresponding voltage shown is "0.00 V". Then set the DAC value to "FFF" and verify a voltage of "9.99V".

The remaining DAC tests (04-11) are basically debugging exercises, intended primarily for factory test purposes.

5.3.5 DEBUG DIAGNOSTICS

The DEBUG diagnostics are provided to troubleshoot the instrument hardware. They are entered from the diagnostic select menu:

DIAGNOSTIC
1:**A**UTO 2:LCD 3:KEY 4:DAC'S 5:DEBUG +:Exit

Press the "5" key to call up the DEBUG diagnostics selection screen:

DEBUG MODE
1:LATCH 2:COMM 3:CTRL +:Exit

Three different debugging screens may be selected.

LATCH DEBUG MODE

Enter a "1" to select the Latch debug screen. This screen will display the names of all the cards and latches found in the system and will allow access to the data in the latches. The display format is:

<Card description> CARD: **0** LATCH: 0
<Latch description> READ DATA: xx

The cursor under the digit following "CARD" indicates that the "Card Description" is the active selection parameter. The number stands for the position of the card in the 2405/2410A card cage. Card cage positions are shown in Figure 5-1.

0	1
4	2
5	3
6	8
7	9

Figure 5-1 Card Cage Board locations (looking into the card cage)

Selection of a card is made by pressing the UP/DOWN arrow keys. As the card cage position number is incriminated or decremented, the corresponding card description is updated. Card slot position numbers and the cards that occupy those positions are listed in Table 5-4. Cards 0-3 are unenclosed cards. Cards 4-9 are enclosed RF cards.

The LEFT/RIGHT arrow keys toggle the active parameter selection between the CARD selection and the LATCH selection. Latch selection is in terms of the card on which a latch is located. A message corresponding to the selected latch is shown on the lower line of the display. Some of the latches are undefined. Latches and their associated cards are listed in Table 5-4.

Each latch selection is either a read only, a write only, or both read and write latch. Latch type is indicated by the READ or WRITE (for write only and read/write latches) message that follows the latch description on the lower line of the display. The "Latch Type" column entry of Table 5-4 uses "R" (Read) or "W" (Write) or "R/W" (Read and Write) to identify the Latch Type. For read only latches, the data display shows the data that is currently being monitored at that latch. No data entry is allowed to a read only latch, so the numeric keys are disabled. For write only latches, the data display indicates the last data written to the selected latch. This data value may be incorrect under certain conditions (e.g., entry into latch debug mode, RF card latches written to through the control card RF bus latches), but will be accurate under most circumstances. Numeric entries are allowed to write only latches. Data entry is in 2 digit hexadecimal format where the data input is automatically terminated after the second digit entry. The numeric keypad is defined identically as for the DAC'S Diagnostic mode described earlier (Section 5.3.4).

Table 5-4 CARD/LATCH DEBUG DESCRIPTIONS

CARD		LATCH		
NO.	DESCRIPTION	NO.	SELECTION	TYPE
0	DDS CARD	0	ID code	R
		1	DDS PGM STROBE	W
		2	4LSDs (16 BIT DATA)	W
		3	4MSDs (16 BIT DATA)	W
		4	.1/.01 Hz PROG	W
		5	10/1 Hz PROG	W
		6	1/.1 kHz PROG	W
		7	100/10 kHz PROG	W
1	MICROPROCESSOR CARD	0	RF data out port	W
		1	RF data in port	R
		2	RF addr out port	W
		3	Interrupt port	R
		4	RAM page sel port	R/W

Table 5-4 CARD/LATCH DEBUG DESCRIPTIONS (Con't)

CARD NO.	DESCRIPTION	LATCH NO.	SELECTION	TYPE
		5	ROM bank sel port	R/W
		6	Aux ddr (data direction) port	R/W
		7	Aux data port	R/W
2	CONTROL CARD	0	ID code	R
		1	RF card select	W
		2	RF addr select	W
		3	RF data out	W
		4	RF data in	R
		5	Undefined latch	W
		6	Attenuator prog	W
		7	Peak detector ctrl	W
		8	A/D data (8 lsbs)	W
		9	A/D data (4 msbs)	W
		10	Modulator select	W
		11	DAC select/ FM range	W
3	CARD NOT FOUND	0	Undefined latch	W
4	RF SYNTHESIZER CARD	0	ID code	R
		1	DAC/PLL/tstpt select	W
		2	DAC/PLL data	W
5	DOUBLER CARD	0	ID code	R
		1	Band/tstpt select	W
6	AM/DIVIDER CARD	0	ID code	R
		1	Band/tstpt select	W
7	OUTPUT AMP CARD	0	ID code	R
		1	Band/tstpt select	W
8	LO/REF CARD	0	ID code	R
		1	Undefined latch	W
		2	LO enable/ ref select	W
		3	PLL data/ register	W
9	REFERENCE SYNTH CARD			
		0	ID code	R
		1	Nref MSD/TP SEL	W
		2	Nref 2 SD/LSD	W

If any of the card descriptions indicate "CARD NOT FOUND", then the ID code of latch 0 of that card slot did not read what it should have. This would indicate that either the card is not in place, that its ID code latch is incorrectly wired, or that there is a problem with the RF data/address bus. Option cards will indicate this if they are not inserted but will pass the RF data/ address bus auto-diagnostics tests (because they are not a requirement). All required cards should be read properly by this debug mode unless there is a hardware problem.

Any changes made to the operation status of the instrument are overwritten when the debug mode is exited and the unit is returned to normal operation. To exit this mode, press the STATUS key.

COMMUNICATION DEBUG MODE

Enter the communication microprocessor (Comm) debug mode from the debug diagnostics select screen (Section 5.3.5.)

Enter a "2" to call up the initial Comm debug screen:

0000: 404142434445464748494A4B4C4D4E4F
PORT: @ A B C D E F G H I J K L M N O

The communication debug mode can be used to display the contents of any addressable location of the communication microprocessor. The starting address is shown in the upper left corner of the display. A cursor is placed under the LSD (least significant digit). The cursor keys may be used to increment and decrement the selected digit and to position the cursor under a selected digit. Addresses are shown in 16 bit hexadecimal format. A title block that indicates the region of memory being displayed is below the address. The region refers to the address of the first byte being displayed (the address above it), and not necessarily that of all the bytes being displayed when region boundaries are crossed. The defined microprocessor regions, address ranges, and memory descriptions are listed in Table 5-5.

Table 5-5 COMM DEBUG DESCRIPTIONS

REGION	ADDR RANGE	DESCRIPTION
PORT	0000-001F	6801 µP int registers
STACK	0080-00FF	µP int RAM for stack
PIA1	0400-04FF	PIA registers (LCD contrast)
PIA2	0800-08FF	PIA registers (keybd scan)
GPIA	0C00-OCFF	GPIB interface device
DPRAM	1000-1FFF	global RAM between the 2 µPs (1 kbyte)
SRAM	2000-3FFF	local RAM (8k- static)
ROMxx	4000-4FFF	bankswitched ROM
ROM	5000-FFFF	non-bankswitched ROM (code section)

Sixteen bytes of data are displayed at a time with the upper line formatted in hexadecimal and the lower line formatted in ASCII. The left and right arrows will position the cursor on the starting address being displayed. The INC/DEC keys will increment/decrement the current address digit. Press the STATUS key to exit this mode.

CONTROL DEBUG MODE

The control microprocessor (Ctrl) debug mode is entered from the debug select screen:

DEBUG MODE
1:LATCH 2:COMM 3: CTRL +:Exit

Enter a "3" to call up the initial Ctrl debug screen. The control microprocessor debug mode functions exactly like the communication microprocessor debug mode, except the control microprocessor can be used to display the contents of any addressable location of the control microprocessor.

Defined microprocessor regions, address ranges, and memory descriptions for the control debug mode are listed in Table 5-6.

Table 5-6 CTRL DEBUG DESCRIPTIONS

REGION	ADDR RANGE	DESCRIPTION
PORT	0000-001F	6801 µP int registers
STACK	0080-00FF	µP int RA for stack
PIA1	0800-08FF	PIA registers (RF data/addr bus)
PIA2	1000-10FF	PIA registers (error intrp inputs)
DPRAM	2000-2FFF	global RAM between the 2 µPs (1 kbyte)
SRAM	4000-5FFF	non-bankswitched local RAM (8k; nonvolatile)
RAMxx	6000-7FFF	bankswitched local RAM (3 banks of 8k; non-volatile)
ROM	8000-FFFF	ROM (code section)

5.4 AutoCal® CALIBRATION

The Wavetek Model 2405/2410A RF Signal Generator uses an almost completely automatic calibration procedure (AutoCal®) to calibrate the circuits that determine output frequency and output power level. The status key is used to implement AutoCal®. The detailed procedure to perform the Model 2405/2410A calibration is described in the following sections.

Turn on the Model 2405/2410A and permit a warm up time of one hour (if necessary).

Press the status key ("Stat") to call up the status key operation select menu:

1:Error 2:Diag 3:Optn 4:Cal 5:Set +:Exit

Note that only the second line of the display is shown above. The second line of the LCD display contains operator selections. The first line of the display shows the current modulation, frequency, and level settings for the unit.

Implement AutoCal®, the Calibration Mode of Operation by pressing the "4" key. Software will save the current instrument settings so they can be restored after performing calibration. During calibration the RF output is turned on, and level, frequency, and modulation values are modified. The initial calibration screen will be called up:

CALIBRATION SELECTIONS
1:Freq 2:Level 3: Default +:Exit

Output frequency or output level may be calibrated in the AutoCal® mode. The output frequency calibration routine is described in section 5.4.1; the output level calibration routine is described in section 5.4.2.

The frequency calibration must be performed before the output power level calibration.

When either calibration routine is selected, the entire calibration procedure must be completed. No exit or abort will be allowed after this point.

5.4.1 FREQUENCY CALIBRATION

Before performing a frequency calibration, factory default data must be entered from the initial calibration screen:

CALIBRATION SELECTIONS
1:Freq 2:Level 3: Default +:Exit

Press a "3" from this display to load factory default values for frequency and level calibrations into memory. The following message will be displayed:

LEVEL & FREQUENCY CALIBRATION DATA
RESET TO FACTORY DEFAULT VALUES

This message is displayed for 2-3 seconds while default calibration data is loaded. A generic table of frequency calibration values and default selection of level flatness calibration frequencies are loaded. The level flatness and linearity calibration factors are reset to 0.0 dB. Then the initial calibration menu is displayed again, ready for another selection.

After entering the default data, press a "1" from the initial calibration menu to call up the menu used to initiate a frequency calibration:

FREQUENCY CAL SELECTIONS
1:FULL 2:VCO1 3:VCO2 4:Date +:Exit

Three separate frequency calibrations may be selected and a calibration date may be entered. Pressing the "1" key will initiate a complete frequency calibration. Pressing the "2" key will calibrate the lower VCO only. Pressing the "3" key will calibrate the upper VCO only. Pressing the "4" key will initiate the procedure to enter a calibration date (described at the end of this section).

Press the appropriate numeric key ("1-3") from the initial calibration menu to select the desired frequency calibration. Each frequency calibration routine is completely automatic and requires no operator input at any step.

Pressing a "1" or a "2" will initiate calibration of the lower VCO and call up the VCO 1 display:

FREQUENCY 275 MHz
CALIBRATION VCO 1 DELAY 60

Pressing a "3" will initiate calibration of the upper VCO and call up the VCO 2 display:

FREQUENCY 390 MHz
CALIBRATION VCO 2 DELAY 60

The bottom line of either calibration display shows the 60 second countdown delay, with the count decreased by 1 every second, that allows a 60 second warm-up time for each VCO to eliminate drift problems. The DELAY message will disappear after reaching "DELAY 1".

During lower VCO calibration, the current frequency being calibrated will be shown. Calibration data will be shown in the right section of the bottom display line. Three data values are shown: the coarse tune DAC value, the loop compensation DAC value, and the FM correction value. The RF synthesizer error voltage is shown immediately above the calibration data. All 4 of these readings are updated as the calibration data is adjusted for each cal step. A typical display will look like:

FREQUENCY VCO 1 +0.32V
CALIBRATION 275 MHz 40 2D 5FD

To calibrate the first calibration point (for each VCO) requires about 10 seconds. Calibration is performed at 2 MHz intervals, taking approximately two seconds for each succeeding calibration point. The loop compensation DAC and coarse tune DAC values are determined every 10 MHz. FM correction is sampled every 5 MHz. These measurements are used to interpolate FM correction values at 1 MHz intervals.

When the lower VCO calibration is complete, the unit will automatically begin calibration of the upper VCO if a complete frequency calibration was requested (the "1" key was the initial key pressed). After the last frequency calibration has been performed the following screen will be displayed for approximately 2 seconds:

FREQUENCY
CALIBRATION COMPLETED

The initial calibration screen will then be recalled:

CALIBRATION SELECTIONS
1:Freq 2:Level 3:Default +:Exit

Press a "4" from the initial frequency calibration menu to call up the screen for the calibration date:

FREQ CAL Last call: xx-xx-xx
DATE Enter: MM-DD-YY +:Exit

The last date entry (Last call) is shown on the top line of the display. The date should be updated every time a frequency calibration is performed. Loading default calibration data will reset the date to 00-00-00. The numeric keys are used to modify the date. The cursor is placed under the digit to be changed, and automatically goes to the next digit when an entry is made. Entries are made in the order shown, (month, day, year). There is no internal verification that valid dates are entered. Modifying the frequency calibration date entry does not affect the level calibration date, which is accessed from the level calibration procedure. Date entries are accessible over the GPIB.

Frequency calibration errors typically are due to hardware problems and require some degree of troubleshooting. Wavetek recommends returning the unit to the factory for troubleshooting and repair.

The peak A/D detector is tested before calibration begins because frequency calibration depends upon it functioning properly. If it fails the test, the following screen will be called up:

FREQUENCY 275 MHz FAIL: A/D ERROR
CALIBRATION +:EXIT

The A/D error can occur only at the beginning of the frequency calibration. Press the status key ("Stat") to recall the initial calibration display.

During frequency calibration the coarse tune DAC is adjusted to make the synthesizer error voltage equal 0.0 V Two errors can occur. If the coarse tune DAC can not be reduced as far as it needs to be, the coarse low fail error will occur:

FREQUENCY 275 MHz FAIL: COARSE LOW
CALIBRATION +:EXIT

If the coarse tune DAC can not be increased as much as it needs to be, the coarse high fail error will occur:

FREQUENCY 275 MHz FAIL: COARSE HI
CALIBRATION +:EXIT

If either error occurs, press the status key to recall the initial calibration display.

The loop compensation DAC values are derived from the coarse tune values. There are no errors associated with them. The FM correction values are determined by adjusting the FM DAC value until the peak A/D value matches a level corresponding to the desired deviation value. Therefore the FM correction values can have the same errors as the coarse tune DAC. That is, it may not be possible to adjust the DAC value low enough (FM DAC Low error) or high enough (FM DAC High error) to reach the desired voltage level. The associated error messages are:

FREQUENCY 275 MHz FAIL: FM DAC LOW
CALIBRATION +:EXIT

FREQUENCY 275 MHz FAIL: FM DAC HI
CALIBRATION +:EXIT

If either error occurs, press the status key to recall the initial calibration display.

If the A/D itself is not stable or the synthesizer error voltage is not stable during the coarse tune or FM DAC adjustments, an FM Unstable error will be generated. The associated error message is:

FREQUENCY 275 MHz FAIL: FM UNSTB
CALIBRATION +:EXIT

5.4.2 LEVEL CALIBRATION

The level calibration routine is semiautomatic when performed using front panel controls. A power meter will be connected to the RF output and the unit tuned from the front panel, according to the power meter readings.

The frequency calibration described in section 5.4.1 should be performed before the output power level calibration to ensure the frequency points used in the level calibration are accurate. If the frequency and level calibrations have been performed, and only an adjustment in either level flatness or linearity is needed, it is not necessary to perform the frequency calibration again.

The LEVEL calibration routine is selected from the initial calibration menu:

CALIBRATION SELECTIONS
1:Freq 2:Level 3:Default +:Exit

Press the "2" key to initiate level calibration and call up the initial level calibration screen:

LEVEL CAL SELECTIONS
1:Flatness 2:Linearity 3:Date +:Exit

Separate procedures are available to calibrate level flatness and level linearity. Pressing the "3" key will initiate the procedure to enter a calibration date (described at the end of this section).

The level flatness calibration process adjusts the level accuracy of the instrument over different frequency settings. This flatness correction is performed at a fixed level output of 0 dBm, and the adjustment corrects for the variations in level across the operating frequencies of the instrument.

The level linearity calibration process adjusts the level accuracy of the instrument over different level settings. Because the level flatness correction is performed at a fixed level output (0 dBm), the linearity adjustment must be performed to correct for the nonlinearities of the level control circuitry. The linearity calibration is performed at a fixed frequency of 300 MHz, with level settings adjusted from +13 dBm to -7 dBm in 1 dB increments.

If the level calibration data has been reset to the default setting (Section 5.4.1), it doesn't matter whether level flatness or level linearity calibration is performed first. Note that whichever calibration is performed last should have nearly 0.0 dB correction factor at the "crossover" point. The crossover point for the level flatness calibration is the 300 MHz frequency calibration point. The 0.0 dB level calibration point is the crossover point for the level linearity calibration.

LEVEL FLATNESS CALIBRATION

To begin a level flatness calibration, enter a "1" from the initial level calibration screen to call up the following screen:

LEVEL CALIBRATION
CONNECT POWER METER

The message to connect a power meter will displayed for approximately 4 seconds. Connect an RF power meter with range from .01 MHz to 1100 MHz to the 2405/2410A RF output connector.

If cable losses are also to be nulled out so that a flat signal is transmitted at the end of a long cable length, connect the power meter to the end of the cable when making the level flatness adjustments.

The level flatness calibration mode screen will appear after the "CONNECT POWER METER" message:

LEVEL CAL UP/DOWN: xx.x dB <- adjust
FLATNESS LFT/RIT: xxxx MHz +:Exit

The top line of the display indicates the procedure being performed (LEVEL CAL) and shows the UP/DOWN arrow cursor keys control output RF (xx.x dB). The "<- adjust" indentifies the value associated with the UP/DOWN arrow keys (xx.x dB) as the value to be adjusted. The bottom line indicates the part of the procedure being performed, the "FLATNESS" procedure, and shows the left/right arrow cursor keys advance the level flatness calibration through the frequency points (xxxx MHz) at which calibration occurs. Three significant digits of frequency are shown. Frequencies less than 1 MHz are shown in kHz units. The "+" key will recall the previous display.

During the level flatness calibration, the 2405/2410A output will be tuned so the power meter reads 0 dBm at each frequency calibration point.

The up and down arrow cursor keys increment and decrement the calibration factor (the "xx.x dB" value required to take the power meter reading equal 0 dBm) at each calibration frequency point.

The right and left arrow cursor keys step forward and backward from one frequency calibration point to the next. The right arrow cursor is used to step forward through the level flatness calibration frequencies. Pressing this key at the last calibration point will display the message "DONE" in place of the frequency display, to indicate there are no more calibration points. When this message is displayed, only the left arrow key, the "+" key and the STATUS key are active. The left arrow cursor is used to recall a calibration point for review. The left arrow key has no effect when the first (lowest frequency) calibration point is displayed.

The "+" key and the STATUS key may be used to exit the level flatness calibration mode and recall the initial level calibration menu.

The level flatness calibration factor (in xx.x dB) for the current frequency calibration point is displayed to the left of the UP/DOWN characters. The Up and Down cursor arrow keys will adjust the level flatness calibration factor in 0.1 dB steps. The RF output at each calibration point should be adjusted to 0.0 dB, using the up/down cursor arrow keys as necessary. The range over which adjustment can occur is from +9.9 dB to -9.9 dB. After all calibration points have been adjusted initially, it is usually beneficial to review the calibration points and refine the adjustments.

The calibration factor displayed indicates the amount of adjustment that was necessary at each calibration frequency, but should not be used as an indicator of how much adjustment to perform.

The following frequencies are points at which level flatness calibration occurs:

10 kHz, 20 kHz, 40 kHz. 60 kHz, 80 kHz, 100 kHz, 200 kHz. 400 kHz, 600 kHz. 800 kHz, 1 MHz, 2 MHz, 4 MHz, 6 MHz, 8 MHz, 10 MHz, 15 MHz, 20 MHz, 40 MHz. 60 MHz, 80 MHz, 100 MHz, 150 MHz, 200 MHz, 250 MHz, 300 MHz, 350 MHz, 400 MHz, 450 MHz, 500 MHz, 550 MHz, 600 MHz, 650 MHz, 700 MHz, 750 MHz, 800 MHz, 850 MHz, 900 MHz, 950 MHz, 1000 MHz, 1050 MHz and 1100 MHz.

If a point can not be adjusted to 0.0 dB, a hardware problem is indicated.

When all calibration points have been adjusted to 0.0 dB, press the "+" key or the STATUS key to exit the level flatness calibration process, and recall the initial level calibration display.

LEVEL LINEARITY CALIBRATION

To begin a level linearity calibration, enter a "2" from the initial level calibration menu to call up the screen:

LEVEL CALIBRATION
CONNECT POWER METER

This message will be displayed for approximately 4 seconds. Connect an RF power meter with range from .01 MHz to 550 MHz to the 2405/2410A RF output connector.

The level linearity calibration mode screen will appear after the "CONNECT POWER METER" message:

LEVEL CAL UP/DOWN: xx.x dB <- adjust
LINEARITY LFT/RIT: xx.x dBm +:Exit

The top line of the display indicates the procedure being performed (LEVEL CAL) and shows the UP/DOWN arrow cursor keys control the output RF (xx.x dB). The <- adjust" identifies the value associated with the UP/DOWN arrow keys (xx.x dB) as the value to be adjusted. The bottom line indicates the part of the procedure being performed, the "LINEARITY" procedure, and shows the left/right arrow cursor keys advance the level linearity calibration through the power level points (xx.x dBm) at which calibration occurs. The "+" key will recall the previous display.

During the level linearity calibration, the 2405/2410A output will be tuned at each calibration point to make the power meter read the same value as the level value shown on the bottom line of the display.

The up and down arrow cursor keys increment and decrement the calibration factor (the "xx.x dB" value required to make the power meter reading equal to the value shown on the display's bottom line) at each calibration level point.

The right and left arrow cursor keys step forward and backward from one level calibration point to the next. Calibration is from +13 dB to -7 dB. The right arrow cursor is used to step backward through the level linearity calibration power levels. Pressing this key at the last calibration point will display the message "DONE" in place of the level display, to indicate there are no more calibration points. When this message is displayed, only the left arrow key, the "+" key and the STATUS key are active. The left arrow cursor is used to recall a calibration point for review. The left arrow key has no effect when the beginning (+13 dB) calibration point is displayed.

The "+" key and the STATUS key may be used to exit the level flatness calibration mode and recall the initial level calibration menu.

The level linearity calibration factor (in xx.x dB) for the current power level calibration point is displayed to the left of the UP/DOWN characters. The Up and Down cursor arrow keys will adjust the level linearity calibration factor in 0.1 dB steps. The range over which adjustment can occur is from +9.9 dB to -9.9 dB. The RF output at each level calibration point should be adjusted using the up/down cursor arrow keys to make the power meter reading equal the level value shown on the bottom line of the display. After all calibration points have been adjusted initially, it is usually beneficial to review the calibration points and refine the adjustments.

The calibration factor displayed indicates the amount of adjustment that was necessary at each calibration level, but should not to be used as an indicator of how much adjustment to perform.

Level linearity calibration occurs from +13 dB to -7 dB, at 1 dB increments.

If a point can not be adjusted so the 2405/2410A level output and the power meter readings are the same, a hardware problem is indicated.

When all calibration points have been adjusted, press the "+" key or the STATUS key to exit the level linearity calibration process, and recall the initial level calibration display.

LEVEL CAL SELECTIONS
1:Flatness 2:Linearity 3:DATE +:Exit

Press a "+" from the initial level calibration menu to call up the screen for the calibration date:

LEVEL CAL Last call: xx-xx-xx
DATE Enter MM-DD-YY +:Exit

The last date entry (Last call) is shown on the top line of the display. The date should be updated every time a level calibration is performed. Loading default calibration data will reset the date to 00-00-00. The numeric keys are used to modify the date. The cursor is placed under the digit to be changed, and automatically goes to the next digit when an entry is made. Entries are made in the order shown, (month, day, year). There is no internal verification that valid dates are entered. Modifying the level calibration date entry does not affect the frequency calibration date, which is accessed in the frequency calibration mode. Date entries are accessible over the GPIB.

5.5 POWER UP TESTS

Each time power is applied to the 2405/2410A (the unit is turned on) it performs an automatic sequence of tests to verify various subsystems are functional. The display shows:

WAVETEK Model 2405/2410A rev 5.0
POWER UP SELF-TEST

The following tests are performed in sequence. As each test is performed, the upper line of the display remains as shown above. The lower line of the display shows the test just completed and the test result. All possible displays for each test are shown. If a test is passed, no fail message will be shown.

1. The communication test detects stuck keys and verifies that the two microprocessors communicate with each other properly. The read/write capability of both microprocessors dual-port RAM is examined. The communication microprocessor verifies it can read and write to its half of the RAM, and requests that the control microprocessor do the same. Data is then passed to the control microprocessor, checked against the value it expected, echoed back to the communication microprocessor, and checked against the value it originally sent. This is the same test as the diagnostic test of dual port RAM.

The model #, software version, and revision level of the communication interface routines are compared from one processor to the other. This verifies that the software for both processors is at the same level, so that there won't be any communication problems. The following messages are displayed on the bottom line to indicate the result of the test:

Communication test: PASSED
Stuck key: xxxxxxx
Dual-port RAM test: FAIL +:CONT

If a stuck key is detected, its key code is displayed (represented by the ""xxxxxxx"). Key codes basically repeat the legend found on the key and are shown in Table 5-7.

TABLE 5-7 STUCK KEY CODES

UP	DOWN
LEFT	RIGHT
RF	MHz/MV
kHz/UV	dBm/%, dBmV
+/-	LCL
FREQ	LVL, STATUS
STR	RCL, LCL
INT AM	POS DEV, EXT OM
INT FM	NEG DEV, EXT PM
EXT AM	MOD OFF
EXT FM	RATE

The numerals 0-9 the decimal "."

The self-test will halt until a stuck key is no longer detected, and will automatically continue when the key is released.

Note that a bad cable or a bad microprocessor card component can also cause a stuck key indication.

2. The RAM test verifies that RAM of both microprocessors can be written to and read from correctly. This is the same as the static RAM and non-volatile RAM test in the auto-diagnostics mode. The test consists of writing patterns to each memory location, reading them back, and comparing what was read to what was written. If any memory location fails to match, an error is indicated. The patterns used are $55 (alternating high and low bits) and $aa (the complement of $55). If an error is found, the selftest will stop until the + key is pressed. Additional tests are performed on the control microprocessor. First it is determined whether an 8k or a 32k RAM is required (dependent on the stored setting option selection). If a 32k device is required, each of the three 8k banks is tested by the read/write process described above. Finally, bank selection is tested by writing a different value to the same location in each of the banks and checking to see if any of the data was corrupted by writing it to another bank.

The following messages indicate the results of this test:

RAM test	PASSED	
Control RAM test:	FAIL	+:CONT
Communication RAM test:	FAIL	+:CONT

3. The ROM test verifies that the PROMs of both microprocessors have the correct check sum. This is the same as the communication EPROM and control EPROM auto-diagnostic tests. If an error is found, the self-test will stop until the + key is pressed. The following messages indicate the results of this test:

ROM test:	PASSED	
Control ROM test:	FAIL	+:CONT
Communication ROM test:	FAIL	+:CONT

4. The non-volatile data test determines that the data in the calibration tables, option table, and powerup instrument settings tables is valid. These tables are stored in the control microprocessor non-volatile RAM. Tables are verified by checking that their checksums match the values that were saved. The powerup instrument settings tables also are checked to make certain that numeric functions are in the proper format and toggle functions have valid values. The option table also is inspected for the correct model number. An error in any or all of these tables may indicate that the non-volatile RAM is failing. (Note that errors may be induced by excessive handling of the microprocessor card or failure of the battery in the non-volatile RAM). Recurrent failure may dictate replacing the non-volatile memory device. If the calibration data is lost, it must be regenerated by performing both a frequency and a level calibration. A powerup instrument settings data failure or an options test failure will result in the powerup settings or options settings being reset to their factory default values. When a failure occurs, any or all of the stored settings may be lost.

An error will cause the self-test to stop until the + key is pressed. The following messages indicate the results of this test:

Non-volatile data test:	PASSED	
Calibration table:	FAIL	+:CONT
Instrument setting:	FAIL	+:CONT
Option table:	FAIL	+:CONT

5. The hardware test checks the hardware interfaces of the microprocessor card. It verifies that all necessary cards are installed properly and that the RF data and address bus is operational. This test determines if the cards are in their correct positions in the card cage by reading the ID code latch on each card. Each card has a specific position in the card cage, so the cards' ID code can be used to verify that each card slot contains the correct card. Card ID codes are list in Table 5-8. If a failure occurs, the card name listed in Table 5-8 is displayed.

TABLE 5-8 CARD ID CODES

Code	Card Name
0	DDS Card
2	Control Card
4	RF Synthesizer Card
5	Doubler Card
6	AM/Divider Card
7	Output Amp Card
8	LO/Reference Card
9	Reference Synthesizer Card

The cards that are required for options (for example, the deviation meter card) are tested only if those options are installed.

Card failure may be caused by a missing card, a defect in the card's ID latch, or a faulty microprocessor/ motherboard RF data/address bus. This test is the same as the auto-diagnostics card ID code test.

The Control card and the DDS card are read directly from the Microprocessor card. If these cards are installed properly and an error is indicated for either of these two cards, the problem can be isolated to the RF data/address port of the microprocessor card, or its connections to these cards. Power supply loss to these cards can also cause a misleading hardware error indication.

Because the Control card is required to read the RF cards, the RF cards are skipped if the Control card cannot be read. If one of these cards gives an error indication (ID codes 4,6-9), even though it is installed correctly, the problem can be isolated to the RF data or address bus between the Control card and the RF cards, or to the Control card latches that drive these lines.

The RF data bus test consists of exercising the RF data bus on the Control card to verify that the data written is written properly. A test failure will indicate a problem localized to the RF data bus or the corresponding latch drivers on the Control card. The control card must be properly installed to perform this test. This test is the same as the RF data bus test in the autodiagnostics mode.

The ADC reference test verifies operation of the ADC on the control card. In order for this test to pass, the control card must be installed properly, its ADC circuitry must be functional, the + 10 V reference must be functioning properly, and the 1 MHz reference frequency from the LO/ref card must be functioning. The test consists of

selecting the 0v ground reference and the + 10 V reference testpoints of the ADC input and performing a positive peak reading of them. The readings fail if the measured values do not fall within a +/- 200 mV window of the indicated value. This test is the same as the first two checks in the DAC/ADC test in the auto-diagnostics mode.

An error will cause the self-test to stop until the + key is pressed to continue testing. The following messages indicate the results of this test:

Hardware test:	PASSED	
<Card name>	FAIL	+:CONT
RF data bus test:	FAIL	+:CONT
ADC 0v ref test:	FAIL	+:CONT
ADC 10 V ref test:	FAIL	+:CONT

After power up tests are completed, the unit is ready for normal operation as detailed in Section 3 of this manual. The unit powers up with the instrument settings that were active when it was last turned off.

If the front panel display does not operate (is blank or exhibits nonsense or a garbage message), the Model 2405/2410A is inoperable and needs repair. Wavetek recommends the unit be returned to the factory, after authorization, for any repair work.

SECTION 6
GPIB

The GPIB command format uses the minimum uniqueness concept to allow considerable flexibility in programming the 2405/2410A functions. Because of this flexibility the Model 2405/2410A with GPIB can be easily conformed to any GPIB based Automated Test Equipment (ATE) system. It also is compatible with most of the command set of the Wavetek 2500 family instruments.

6.1 INTRODUCTION

The general purpose interface bus (GPIB) in the Model 2405/2410A is fully compatible with IEEE Std 488-1978 and 1987. The following interface functions are implemented.

SH1 Complete source handshake capability
AH1 Complete acceptor handshake capability
T6 Basic talker, serial poll; unaddressed if MLA (my listen address) is active; talk only mode disabled
TE0 Extended talker mode disabled
L4 Basic listener; unaddressed if MTA (my talk address) is active; listen only mode disabled
LE0 Extended listener mode disabled
SR1 Complete service request capability
RL1 Complete Remote/Local capability
PP0 Parallel poll capability disabled
DC1 Complete deviceclear capability
DT1 Complete device trigger capability
C0 Controller capability disabled
E2 Device dependent code to data line to indicate end of string; bit 2 (of bits 1-8) must be set.

All instrument functions except Power On/Off may be set via the GPIB. The Model 2405/2410A is both a listener and a talker over the GPIB. It also provides error status and instrument status to its associated computer/controller.

6.2 INSTALLATION INSTRUCTIONS

The GPIB circuitry is located on the dual microprocessor card inside the Model 2405/2410A. The bus address (My Listen Address; MLA) for the Model 2405/2410A is factory preset at "2", but this may be changed over the GPIB or through the front panel diagnostics procedure if desired. The acceptable terminator characters are carriage return (decimal 13), linefeed (decimal 11), and the issuance of an EOI (end or identify) with the terminating character. All response messages are terminated with a linefeed character along with an EOI signal. This terminator character may also be changed over the GPIB or through the front panel. Installation associated with GPIB control of the 2405/2410A consists of using a GPIB cable to connect a GPIB controller to the GPI connector on the rear panel of the 2405/2410A.

A GPIB controller is a digital computer that has I/O interface hardware and an operating system that is compatible with the IEEE-488 standard. The controller sends ASCII command strings over the GPIB to control a GPIB instrument. Verify GPIB operation by sending the simple carrier frequency command "FRQ 200 MHz" over the bus. (The complete command entry will depend upon the controller used. See Sections 6.3.5 and 6.3.9 for greater detail.) The 2405/2410A FREQUENCY display will show 200 MHz and the second line STATUS display will show the REMOTE annunciator if installation is correct.

6.3 OPERATING INSTRUCTIONS

6.3.1 LOCAL/REMOTE MODE SELECTION

When power is first applied to the Model 2405/2410A the instrument will be in the Local Mode of operation. All functions will be controlled from the front panel. The 2405/2410A will enter the Remote Mode of operation after any valid command has been transferred over the GPIB bus. When the 2405/2410A is in the remote mode, the front panel keypad is inactive with one possible exception. The LCL key may be used to switch operation back to the Local Mode if the Local Lockout bus command has not been sent by the controller. Note that if the GPIB has been used to send Local Lockout, the 2405/2410A front panel is totally inactive (except for the power on/off switch) and the keyboard cannot be used to make changes in operating functions/values.

When the unit is on the local mode with a STATUS menu displayed, no GPIB commands will be accepted, and no handshaking on the bus will occur. Exiting from the STATUS menus will re enable GPIB operation.

Three procedures may be used to switch from remote mode to local mode. The operator may cycle power (turn the 2405/2410A off, then on), with power up in the local mode. The operator may press the LCL key on the 2405/2410A front panel (if the Local Lockout Command has not been sent over the GPIB). The operator may send the return to local mode (RTL) command over the GPIB. Either of these three procedures will return control to the 2405/2410A front panel. The unit will not enter the local mode while valid GPIB commands are being sent.

6.3.2 ADDRESS SETTING

The MLA (My Listen Address), the 2405/2410A instrument bus address, is programmable over the GPIB and from the front panel using STATUS menus. The power up (default) address is factory preset at "2". The default MLA can be changed by reprogramming through the diagnostic mode or reprogramming over the GPIB bus. SIG (signal generator), MLA (my listen address), and MTA (my talk address) are all methods of changing the programmable instrument address over the GPIB bus. The talk and listen addresses must be the same. Only a decimal address of 0-30 is allowed. An error will be generated if the programmed address is out of range and the current address will not be changed. The last valid address set through the diagnostics procedure is the power-up default address. The 2405/2410A allows only primary addressing.

6.3.3 GPIB INPUT COMMAND DEFINITION

A GPIB input command is a statement generated by the controller and transmitted to the 2405/2410A by the GPIB that causes the 2405/2410A to execute a particular function or establish a particular setting.

The Wavetek 2405/2410A GPIB recognizes a variety of input commands to provide maximum user friendliness. The majority of the GPIB input commands are identical in format to their corresponding manual entries through the front panel keyboard. The remaining GPIB commands are used to obtain system status information or to change system status.

The GPIB command structure is case-insensitive. That is, upper and lower case ASCII characters are accepted as the same ('A' and 'a' are equivalent). Also, any ASCII control character (dec value < 32) that is not a terminator character is accepted as an ASCII space character. The ASCII space character is used to separate the parts of a command from each other. The terminator characters are the carriage return, linefeed, and whatever the programmable character is set to. An EOI (End-Or-Identify) signal sent across the GPIB interface also acts as a terminator character. These characters are used to terminate all commands (with the exception of the DDT command). The command seperator character (an ASCII semicolon ";") also terminates a command, and is used for concatenating commands on a single string sent from the controller.

6.3.4 GPIB INPUT COMMANDS

All commands consist of a command header and an optional argument. The header is the part of the command that describes the type of function to execute. The argument consists of the data for the command to act upon.

The 2405/2410A GPIB uses the "minimum uniqueness" concept when accepting the command headers. This concept consists of identifying a command header by comparing it to both a minimum and a maximum format. The header must consist of at least the minimum format sequence of characters. Further, all of its characters must be contained in the maximum format in the same order of occurrence. Any command obeying these 2 rules will be accepted. As an example, the minimum format for the frequency setting command is FRQ and the maximum format is FREQUENCY. Therefore FRQ, FREQ, FRQNCY, and FREQUENCY are all acceptable formats since they all contain the characters FRQ in order, and all of their characters are contained in order in FREQUENCY. FQNCY and SFRQ would not be accepted, since FRQ is not contained in FQNCY and SFRQ is not contained in FREQUENCY. Table 6-1 lists all of the GPIB command headers accepted in both their maximum and minimum formats.

The GPIB commands are classified according to the type of arguments they are associated with. There are five (5) classifications of GPIB commands: numeric, status, direct, query, and special. Some command headers may be used with more than one type of argument type, and are shown as such in Table 6-1. Some numeric commands have alternate forms. Although the command names are different, they are identical in operation. These commands are:

Level LVL = AMP
Moderate RTE = MFQ
GPIB Address MLA = MTA = SIG

Each type of command and its format are described in the following sections.

TABLE 6-1. COMMAND HEADER FORMATS

	MAXIMUM FORMAT	MINIMUM FORMAT	ARGUMENT TYPES Numeric	Status	Direct	Query	Special
	FREQUENCY	FRQ	X	-	-	X	-
	LEVEL	LVL	X	-	-	X	-
	AMPLITUDE	AMP	X	-	-	X	-
	INTERNALAM	IAM	X	-	-	X	-
	INTERNALFM	IFM	X	-	-	X	-
	EXTERNALAM	XAM	X	-	-	X	-
	EXTERNALFM	XFM	X	-	-	X	-
*	EXTERNALPHASEMOD	XPH	X	-	-	X	-
	MODRATE	RTE	X	-	-	X	-
	MODFREQUENCY	MFQ	X	-	-	X	-
*	DUTYCYCLE	DTY	X	-	-	X	-
	STEPSIZE	STP	X	-	-	X	-
**	CURSORPOSITION	POS	X	-	-	X	-
	STORE	STR	X	-	-	X	-
	RECALL	RCL	X	-	X	X	-
	MYLISTENADDRESS	MLA	X	-	-	-	-
	MYTALKADDRESS	MTA	X	-	-	-	-
	SIGNATURE	SIG	X	-	-	-	-
	RFPOWER	RF	-	X	-	X	-
*	EXTERNALPULSEMOD	XPL	-	X	-	X	-
*	INTERNALPULSEMOD	IPL	-	X	-	X	-
	REQUESTFORSERVICE	RQS	-	X	-	X	-
	MODULATION	MOD	-	X	-	X	-
	LEVELFORMAT	LFMT	-	X	-	-	
	RETURNTOLOCAL	RTL	-	-	X	-	-
	REMOTE	REM	-	-	X	-	-
	LOCALLOCKOUT	LLO	-	-	X	-	-
	GROUPEXECUTETRIG	GET	-	-	X	-	-
	DEVICECLEAR	DCL	-	-	X	-	-
	RESET	RST	-	-	X	-	-
	INCREMENT	INC	-	-	X	-	-
	DECREMENT	DEC	-	-	X	-	-
	ERROR	ERR	-	-	-	X	-
	SETTINGS	SET	-	-	-	X	-
	HELP	HLP	-	-	-	X	-
	IDENTIFY	ID	-	-	-	X	-
	AUTOFREQUENCYCAL	AFC	-	-	-	X	-
	OPTIONS	OPT	-	-	-	X	-
**	KEY	KEY	-	-	-	X	-
	TERMINATORS	TRM	-	-	-	-	X
	DEFINEDEVICETRIG	DDT	-	-	X	X	X
	CALIBRATION	CAL	-	-	-	X	X
**	TEST	TST	-	-	-	X	X
	IF	IF	-	-	-	X	X
	THEN	THEN	-	-	-	-	X
	ELSE	ELSE	-	-	-	-	X
**	DISPLAY	DISP	-	-	X	-	X

Notes: * command is an optional feature ** command requires the extended GPIB feature be enabled

6.3.4.1 COMMAND FORMAT DESCRIPTION TERMINOLOGY

The following symbols will be used to describe the command formats in the following sections:

[ ] - Indicates an optional character or string

{ } - Indicates the data between the brackets may be repeated

sp - One or more ASCII space characters (hex 20)

; - A terminator character (CR, LF, EOI, programmable terminator character, or command separator character ";"

<mantissa> - A string of decimal characters (0-9) with at most 1 decimal point, having a maximum length of 28

<sign> - Either the ASCII + or - character

Note: sign is assumed positive if none is given

<exponent> - A string of decimal characters (0-9) having a range of 0 to 99 with no leading 0's

<unit> - One of the character strings defined in Table 6-4

<hex string> - A string of hexadecimal characters (0-9 and A-F)

<comparator>- One or more of the following symbols: < > =

The GPIB characters recognized by the 2405/2410A consist of the following:

0 - 9 Decimal (BCD) digits

A - Z Alpha characters for command headers and arguments A - F also used as hexadecimal argument values E also used as numeric exponent indicator

a - z (same as (A - Z)

. Decimal point used for separating integer portion of numeric argument from the fractional portion

+,- Sign for numeric mantissa and exponent value (+ assumed if absent)

space Separates the command header from the argument

; Separates commands when more than 1 command is output per line

CR,LF Terminates a command

? Terminates a query command

% Used to specify percent units for int and ext AM parameters

! End of record terminator for the DDT command

>,<,= Used to specify comparison for IF command

6.3.4.2 NUMERIC COMMANDS

Numeric commands have arguments that can be expressed as numeric values (integer or floating point) in engineering or scientific notation. These consist of the commands that specify numerical values for the instrument such as frequency, level, and modulation values. The argument value for these commands are limited to the range for the specified parameter. The value is also limited to the minimum resolution of the parameter. If greater resolution is given than the parameter is allowed, the value is rounded to the nearest value within resolution. The rounding is performed before testing the range limits, so a value less than the range limit can be flagged as an overrange error if it exceeds the range limit after the value is rounded. Rounding is only performed on the commands that specify the unit settings, all other commands truncate the input value. These are all of the unit less settings: store (STR), recall (RCL), GPIB address (MLA, MTA, SIG), and cursor position (POS). The functions of the numeric commands are outlined in Table 6-2.

Range limits and resolutions for the numeric commands are given in Table 6-3. Some parameters (e.g. LVL, IFM, XPH) have different resolutions depending on the range of values that the setting falls between. These resolutions are the same as the values that are displayed on the front panel. Also note that the upper range limit on IFM and XFM are lower when the operating frequency is in the divider band range (137.5 - 275 MHz). This is due to a limitation of the hardware. The upper range limit of external phase mod is depen-

dent on the type of option installed. One version has a 20 rad max limit and the other has a 50 rad limit.

Valid values for mod rate are dependent on whether the variable mod rate (VAR) option is installed. If not, only 400 Hz and 1000 Hz are valid. If VAR is installed, the range listed in the table is valid.

The maximum valid cursor position is 79 (corresponding to the last character of line 2). A range error is not flagged for any value, however. Values greater then 80 are set to position 0. Position 80 is invalid and should not be used.

All of the numeric commands (except the GPIB address) also function as query commands. These will be discussed in Section 6.3.4.5. The recall function also functions as a direct (no argument) command for incriminating through the stored settings. This use of the RCL command is discussed in Section 6.3.4.4.

The format for the numeric command is:

<header> sp <numeric argument> ;

Where <numeric argument> can be defined in one of 3 ways:

[<sign>] <mantissa>
[<sign>] <mantissa> E [<sign] <exponent>
[<sign>] <mantissa> <unit>

The first method is called open notation and uses no exponent and no unit identifier. The exponent value is assumed to be 0 and the unit having an equivalent exponent of 0 is chosen. If the level is being set, the level format will remain unchanged. Examples are:

FRQ 1234567.8	sets the unit frequency to 1.2345678 MHz
IAM 15	sets internal am to 15 %
STR 14	stores the current instrument settings in location 14
LVL 0.8	sets the unit level to 800 mV if current format = volt sets the unit level to .8 dBm if current format = dBm

The second method is called scientific notation since it represents the value by a mantissa followed by an exponent value. The units identifier is again the one having an equivalent exponent value of 0 and the level format will remain unchanged. Examples are:

FRQ 1.2345678 E +6	sets the unit frequency to 1.2345678 MHz
IFM 22.34E3	sets internal FM to 22.34 kHz

The third method, called engineering notation, specifies the units for the parameter. The allowable units are listed in Table 6-4. This is the only method that can also change the format of the level. Note that several parameters have no listing in this table. These parameters are unit less, and do not need this notation. The parameters are: STR, RCL, MLA, MTA, SIG, and POS. No checks are performed to match units with the parameter, so MV may be used with FREQUENCY and no error will be flagged. The only effect of the units is to select the exponent value associated with the unit. Examples using this method are:

FRQ 1.2345678 MHz	sets the unit frequency to 1.2345678 MHz
LVL -12.3 dBmV	sets the unit level to -12.3 dBmV

TABLE 6-2. NUMERIC COMMAND DESCRIPTIONS

FREQUENCY	FRQ	set the value of the RF output frequency
LEVEL AMPLITUDE	LVL AMP	set the RF output level (same as LEVEL)
INTERNALAM	IAM	set the internal AM percentage modulation (also enables the internal AM and disables internal FM and external AM)
INTERNALFM	IFM	set the internal FM deviation frequency (also enables the internal FM and disables internal AM, external FM, and external phase mod)
EXTERNALAM	XAM	set the external AM percentage modulation assuming a 1 V peak-to-peak signal is input (also enables the external AM and disables internal AM, external FM, and external phase mod)

TABLE 6-2. NUMERIC COMMAND DESCRIPTIONS (Con't)

EXTERNAL FM	XFM	set the external FM deviation frequency assuming a 1 V peak-to-peak signal is input (also enables the external FM and disables internal FM, external AM, and external phase mod)
EXTERNAL PHASE MOD	XPH	set the external phase mod value assuming a 1 V peak-to-peak signal is input (also enables the external phase mod and disables internal FM, external AM, and external FM)
MOD RATE	RTE	set the internal modulation rate
MOD FREQUENCY	MFQ	(same as MODRATE)
DUTY CYCLE	DTY	set the internal pulse mod duty cycle
STEP SIZE	STP	set the size of the frequency step (used with the INC and DEC commands)
CURSOR POSITION	POS	set the cursor position to a given value (this command is an extended GPIB command whose operation is further defined in Section 6.3.7)
STORE	STR	store the current instrument setting at the specified location
RECALL	RCL	recall a specific instrument setting previously stored away
MY LISTEN ADDRESS	MLA	set the GPIB talk & listen address
MY TALK ADDRESS	MTA	(same as MYLISTENADDRESS)
SIGNATURE	SIG	(same as MYLISTENADDRESS)

TABLE 6-3. NUMERIC COMMAND RANGES & RESOLUTIONS

PARAMETER	MIN RANGE	MAX RANGE	RESOLUTION
FREQUENCY	10.0 kHz or 10.0 Hz(if LEX option installed)	1100.0 MHz	0.1 Hz
LEVEL	-127.0 dBm	+ 13.0 dBm	0.1 dBm
	- 80.0 dBmV	+ 60.0 dBmV	0.1 dBmV
	- 20.0 dBuV	+120.0 dBuV	0.1 dBuV
	0.10 uV	9.99 uV	0.01 uV
	10.0 uV	99.9 uV	0.1 uV
	100.0 uV	999.0 uV	1.0 uV
	1.00 mV	9.99 mV	0.01 mV
	10.0 mV	99.9 mV	0.1 mV
	100.0 mV	1000.0 mV	1.0 mV
INTERNALAM	0.0 %	100.0 %	0.1 %

TABLE 6-3. NUMERIC COMMAND RANGES & RESOLUTIONS (Con't)

PARAMETER	MIN RANGE	MAX RANGE	RESOLUTION
INTERNAL FM	0.0 kHz	99.9 kHz	0.1 kHz
	100.0 kHz	1000.0 kHz	1.0 kHz
		or 500.0 kHz (if Freq >= 137.5 MHz and < 275.0 MHz)	
EXTERNAL AM	0.0 %	100.0 %	0.1 %
EXTERNAL FM	0.0 kHz	99.9 kHz	0.1 kHz
	100.0 kHz	1000.0 kHz	1.0 kHz
		or 500.0 kHz (if Freq >= 137.5 MHz and < 275.0 MHz)	
EXTERNAL PHASE MOD	0.000 rad	9.999 rad	0.001 rad
	10.00 rad	20.00 rad	0.01 rad
		or 50.00 rad (depending on option)	
MOD RATE	400 Hz	1000 Hz	——
	If VAR is not installed, only the 2 values listed are accepted as valid		
	If VAR option is installed, the following range limits apply:		
	1.0 Hz	100.0 kHz	1.0 Hz
DUTY CYCLE	0	100	1
STEP SIZE	10.0 kHz	1100.0 MHz	0.1 Hz
CURSOR POSITION	0	79	1
STORE	0	19	1
		or 99 (if extended memory option)	
RECALL	0	19	1
		or 99 (if extended memory option)	
MY LISTEN ADDRESS	0	30	1

TABLE 6-4. NUMERIC COMMAND UNITS

UNITS		EXPONENT	COMMANDS
GHZ	GZ	+9	FRQ, IFM, XFM, RTE, MFQ, STP
MHZ	MZ	+6	" " " "
KHZ	KZ	+3	" " " "
HZ		+0	" " " "
RADS	RAD	+0	XPH
DBMV		+0	LVL, AMP
DBUV		+0	" "
DBM		+0	" "

TABLE 6-4. NUMERIC COMMAND UNITS (Con't)

UNITS	EXPONENT	COMMANDS
MV	-3	" "
UV	-6	" "
VOLT V	+0	
%	+0	IAM, XAM, DTY

6.3.4.3 STATUS COMMANDS

Status commands have arguments that describe a status or condition that the user wishes to set. Each command has a limited number of arguments that it can be used with. Table 6-5 lists the status commands along with all of the valid arguments it can be used with and a description of the function performed by each.

The format for the status command is:

<header> sp <status argument> ;

Where <status argument> is one of the arguments listed in Table 6-5. Some additional information about a few of the commands is given in the following paragraphs.

The MOD OFF command is used not only for turning off all modulation currently enabled.

The LFMT command is used for converting the format of the level setting. The level value itself does not change using this command. The only affect it has is on how the level setting is displayed, and how the unit responds to a level setting query. Also, if the engineering notation is not used with a level setting numeric command, this command can precede the level setting command to select the format to be used (see Section 6.3.4.2).

TABLE 6-5. STATUS COMMAND DESCRIPTIONS

COMMAND	ARGUMENT	DESCRIPTION
MOD	OFF	- Disable all modulation (IAM, IFM, IPM, XAM, XFM, XPM, XPH)
RF	OFF	- RF output signal disabled at the RF OUT connector on the front panel
RF	ON	- RF output signal enabled at the RF OUT connector on the front panel
RQS	OFF	- Disable service request for any status indication
RQS	ON	- Enable service request to be issued for an error condition and when the output buffer has a message available
XPL	OFF	- Disable external pulse mod (other mods not affected)
XPL	ON	- Enable external pulse mod (and disable internal pulse mod if enabled)
IPL	OFF	- Disable internal pulse mod (other mods not affected)
IPL	ON	- Enable internal pulse mod (and disable external pulse mod if enabled)
LFMT	dBmV	- Convert level setting to dBmV format
LFMT	dBuV	- Convert level setting to dBuV format
LFMT	dBm	- Convert level setting to dBm format
LFMT	VOLT	- Convert level setting to volt format
LFMT	V	- (same as LFMT VOLT)
LFMT	MV	- (same as LFMT VOLT)
LFMT	UV	- (same as LFMT VOLT)

The RQS ON and RQS OFF commands are used for enabling and disabling the service request line on the bus when either an error condition occurs or there is one or more messages in the output buffer waiting to be read. The service request line is a way of getting hold of the GPIB controller's attention to flag a condition that needs attention. The service request is not necessary to read errors or messages, or even to determine if either condition has occurred. The serial poll register may be read at any time by the controller to determine the current status of the instrument. The command to perform this varies from controller to controller, but is often a command similar to either "SPOLL" or "STATUS". The serial poll register operation and error messages are discussed in further detail in Section 6.3.5.

6.3.4.4 DIRECT COMMANDS

Direct commands have no arguments. They consist of the command header only.

The format for the direct command is:

<header> ;

Table 6-6 lists the direct commands along with a brief description of the function performed by each. Additional information about a few of the commands is given in the following paragraphs.

The REM command is a dummy command. Its only function is to set the unit to the remote mode, disabling the front panel keys. All GPIB commands except for the RTL command put the unit in the remote mode. The front panel keys can be re-enabled by sending the command RTL or by pressing the LCL key on the front panel. The LLO command functions the same as the REM command, except that the front panel LCL key is also disabled. Only the RTL bus command can re-enable the front panel keys once this command has been issued and the unit is in remote. The only way to disable lockout is by turning the unit off and on.

The DDT command clears the Group Execute Trigger buffer when it is used without an argument. The same command can be used to load commands into the GET buffer and to query the current contents of the buffer, and these are discussed in the appropriate sections.

The GET command will execute any commands that have been placed in the buffer. If the buffer is empty (its powerup default condition and after the DDT or DCL direct commands are issued) the GET command performs no actions other than put the unit in remote mode. Some commands have special properties when executed from the GET command. These are discussed in detail in Section 6.3.8.

The RCL direct command recalls the next valid stored setting location, skipping over any locations that contain invalid (uninitialized) data. If there are no valid settings stored away, this command has no effect (a recall query command will indicate setting 0). When a setting is stored to a location, that location should contain valid data unless the nonvolatile RAM is defective. If this occurs, the unit should be sent back to the factory for replacement of the device. When this device is replaced, the unit must be re-calibrated for proper operation.

The DISP direct command restores the front panel display to its normal operating mode status. This is an extended GPIB command, and is only used for restoring the display after a message was written to it using the special format of this command. See Sections 6.3.4.6 and 6.3.7 for more details on the use of this command.

Some of the direct commands are equivalent in function to the remote messages defined by IEEE-488.1. These remote messages are single byte commands that are defined by the standard for all instruments, and are different from the standard commands in that the attention (ATN) line on the bus is asserted (set to a 1) while the command is sent, and no arguments can be included with them. The command strings that are defined for the 2405/2410A are sent as data bytes with the ATN line set to a 0 logic level. Since the remote messages cannot have arguments, they can only mimic the direct command strings, which also have no arguments. The following list indicates the command string equivalents of the remote messages:

Remote message		Command string equivalent
GTL	(dec 01)	RTL
LLO	(dec 17)	LLO
SDC	(dec 04)	DCL
DCL	(dec 20)	DCL
GET	(dec 08)	GET

TABLE 6-6. DIRECT COMMAND DESCRIPTIONS

RETURN TO LOCAL	RTL	- Return control to the front panel
REMOTE	REM	- Disable all front panel keys (except LOCAL, if LLO has not been sent)
LOCAL LOCKOUT	LLO	- Disable all front panel keys
DEFINE DEVICE TRIG	DDT	- Reset the GET buffer to empty
GROUP EXECUTE TRIG	GET	- Execute the commands contained in the GET buffer
DEVICE CLEAR	DCL	- Initialize the GPIB buffers, reset the GPIB operating status, delete all pending GPIB input commands and output messages, reset the GET buffer, disable the extended GPIB mode, and reset any pending command execution errors.
RESET	RST	- Resets the instrument settings to factory default conditions. These settings are described in detail in Section 3.6.5.
INCREMENT	INC	- Increments the current frequency value by the step size value (set by the STP command)
DECREMENT	DEC	- Decrements the current frequency value by the step size value
RECALL	RCL	- Recall the next valid stored setting location
DISPLAY	DISP	- Reset the display to the normal operating status (used to restore the display after modifying it using the special format of this command)

6.3.4.5 QUERY COMMANDS

Query commands are used to request information from the 2405/2410A. This information can be on error status, operating parameter values, calibration, diagnostics, or a variety of other sources.

The general format for the query command is:

<header> [sp] ?

The only exception to this format is the TST command, which will be briefly discussed in this section and more thoroughly in section 6.3.7. The query commands include a mixture of numeric functions, status functions, and special functions, as well as commands that function only as a query. All queries return one or more responses for the controller to read, and all messages are 30 characters in length, plus a terminator character. Table 6-7 gives a list of all of the available query commands, and a brief description of the information they return.

The AFC? command causes the unit to enter the auto frequency calibration mode, and generate new calibration data for the unit. This process generally takes about 8 to 12 minutes to complete, and the controller is notified by the "message available" flag in the serial poll register when the process is complete. The response will indicate if there were any failures. Once this command is issued, no further commands will be processed until this one completes. During the calibration process, the front panel will have the following message placed on it:

Remote Frequency Calibration in Process
275 MHz

The frequency display will increment from 275 to 545 MHz in 5 MHz intervals while performing the calibration. The RF output will be on during calibration so that the frequency can be monitored for debugging purposes. During each frequency step, the frequency switches from the value that is displayed to 1 MHz above this value. FM is alternately enabled and disabled as well. The response message returned will be one of the following, depending on whether any errors occurred during calibration:

AFC ? - "AFC PASSED "
"AFC FAILED "

All of the numeric and status commands (except for GPIB address and level format conversion commands) can also function as query commands. The response message generated for each of these queries will reflect the current status of selected parameter. This can be useful for determining whether a command was correctly executed as well as verifying that the resolution of the parameter was not exceeded. Table 6-8 lists all of the numeric and status query commands and the format of their responses. The numeric responses are formatted in the same manner as the front panel display of their values. The table indicates typical numeric values using the character "x" to represent the actual numeric data. Some parameters, however, use various units or different resolution values depending on the magnitude of the parameter. Table 6-3 indicates the resolutions and units for the numeric parameters.

The POS? command returns the current cursor position (indicated by the "pp" at the start of the response string in Table 6-8), along with 27 chars that are displayed at that location on the LCD display. The characters in the string (indicated by the string of c's in Table 6-8) are the same ASCII characters displayed on the LCD with a few exceptions. The exceptions are for ASCII control characters, non-ASCII characters, and three special characters, none of which are used by the 2405/2410A software. By using this command along with its numeric form, the user may read any or all of the display. This command is only valid if the extended GPIB features is enabled.

The status query commands return the current status of the selected parameter. Only one of the messages listed in Table 6-8 will be output for a given query. All of these commands select between one of two responses, except for the MOD? command. This command reports, in a shorthand form, all of the modulations currently enabled. As the table indicates, there are a large number of possible modulation combinations. Note that PM indicates pulse mod and PHM indicates phase mod.

Six (6) of the commands can return more than 1 response message. These multiple message commands are: HLP?, ERR?, OPT?, SET?, DDT?, and CAL?.

The HLP? Response is always 2 fixed messages, which give the user a phone number for customer service in the event the unit needs repair. It is mostly used as a test message for verifying controller read operations. The response messages are:

HLP ? - "501-CALL WAVETEK RF PRODUCTS "
"501-SALES OFFICE 317-788-9351 "

The ERR? responds with a list of messages that describe the current error conditions, if any. Table 6-9 consists of all of the possible error message responses. Although any number of the powerup and hardware errors may exist concurrently, only one command execution error will exist at a time. Each error message begins with a 3-digit error code, followed by a brief descrip- tion of the error condition. The 1st digit of the error code is defined as follows:

0: powerup error
1: command execution error
2: hardware error
4: no error

The next 2 digits identify the specific error within each classification.

The OPT? command is used to find out what options, if any, are installed in the 2405/2410A. Currently there are 12 options available, each generating one of the following messages:

OPT ?- "OPT:100 STORED SETTINGS "
"OPT:FREQUENCY DOUBLER "
"OPT:DEVIATION METER "
"OPT:VARIABLE MOD RATE "
"OPT:EXT PULSE MODULATION "
"OPT:INT PULSE MODULATION "
"OPT:EXTENDED POWER "
"OPT:20rad EXTERNAL PHASE MOD "
"OPT:50rad EXTERNAL PHASE MOD "
"OPT:LOW FREQ EXTENSION "
"OPT:400 Hz SELECTABLE MOD RATE "
"OPT:150 Hz SELECTABLE MOD RATE "

Note: that either the 20 or 50 rad peak phase mod may be installed in a unit, but not both. The same is true for the 400 Hz and 150 Hz selectable fixed mod rates. There may be other hardware restrictions on available options, but this will be discussed in Section 1.3 on

options. The internal pulse mod option is automatically added when both external pulse mod and variable mod rate options are installed. If the 2405/2410A contains no options, the following message will be displayed:

OPT ? - "NO OPTIONS INSTALLED "

The SET? command is used to request several of the instrument setting values and status. It returns the same information as performing the individual queries, but does so in a single command. The equivalent discreet query commands are, in order:

FRQ, LVL, IAM, IFM, XAM, XFM, XPH, RTE, MOD, RF

The XPH command is only included if external phase mod is installed in the unit. The number of messages returned by this command is 9 if external phase mod is not installed and 10 if it is. Refer to the discussion of the numeric and status query commands earlier in this section for more detail on the format of the individual messages.

The DDT? command is used to review the current status of the group execute trigger (GET) buffer. Upon powerup, the GET buffer is empty, and the following message is returned:

DDT ? - "GET BUFFER EMPTY "

The buffer is also empty after executing either the DCL or DDT direct commands (see sect 6.3.4.4). When the DDT special command is used (see sect 6.3.4.6), commands are inserted into the buffer to be executed at a later time with the GET command. Unnecessary spaces and terminator characters are eliminated, and lowercase characters are converted to uppercase. The maximum buffer length is 512 bytes, so a maximum of 128 commands can be stored (minimum command length of 3 plus terminator). A more typical limit is 50 commands (approximately 10 characters per command average). For more information, see section 6.3.8.

The CAL? command is used to review the current calibration table information. The number of messages returned by this command depends on the number of level flatness commands defined for the instrument. For the 2405/2410A with no options, the default number of messages is 116. If more level flatness frequencies are added to the unit, the equation for determining the number of messages is 70 + (13 * INT (LFnumber/12)) + INT (LFnumber/6) where LFnumber is the number of level flatness frequencies defined for the unit, and INT () represents taking the integer portion of the value within the parenthesis. This number is 42 in the default condition, yielding 70 + (13 * 3) + 7 = 116. The cal data returned is classified into 8 categories:

TABLE NAME	CODE	# OF MSGS
Level Date	LD	1
Level Flatness Frequency	LF	6 - 43
Level Flatness Cal data	LC	39 - 286
Level Linearity	LL	2
Frequency Date	FD	1
Frequency Coarse Dac Data	FC	3
Frequency Loop Comp Dac Data	FL	3
Frequency FM dac data	FM	46
TOTAL		101 - 385

A description of what these tables represent and how they are used is given in section 6.3.6. The above list indicates the number of messages for each of the tables and is given in the same order that the messages are output. The format of the calibration query response is the same as the select code and argument of the calibration special command.

The ID? command is used to identify the instrument being addressed by the bus (GPIB). The standard IEEE-488 format is used. This format breaks the response into 4 fields, each separated by a comma. The first field identifies the instrument manufacturer, the second field specifies the model number of the instrument, the third field indicates the serial number of the unit, and the fourth field the unit revision number. Any unused fields must be set to 0. Only three of the fields are specified, with the serial number value set to 0. The revision number refers to the software revision, and is indicated by "x.x" in the following response:

ID ? - "WVTK,2405/2410A,0,Fx.x "

The KEY? command is used to read the next front panel key that is pressed. The "message available" flag is not set in the serial poll register until a front panel key is pressed. The key descriptor labels used in the front panel key diagnostics test (see section 5.3.3) are used as the response message, along with the key alpha character value used to internally identify the key. This command is only available if the extended GPIB diagnostics is enabled, and generally used for diagnostic purposes only. As an example, the following message would be returned if the frequency key were pressed following this command:

KEY ? - "KEY 40:FREQ "

The TST query command is used to obtain the result of a diagnostic test, or to examine registers, latches, dac values, or the contents of memory. This is the only query command that requires an argument to be included between the TST command header and the question mark. The argument contains information that specifies the diagnostic or parameter value to return. This command requires the extended GPIB diagnostics to be enabled, and is explained in more detail in section 6.3.7.

The IF? command is used to indicate whether the last IF special command resulted in a true or a false condition. This is useful if the controller needs to know if a parameter reaches a certain value, and would prefer to not have to read the numeric query result and compare to this value. Instead, the IF special command (see section 6.3.4.6) can be used to compare the selected numeric parameter value to a fixed value, and this query command can then be used to determine the result. Only the first character of the response needs to be checked to determine if the condition was met. The following two messages will indicate the result:

IF ? - "TRUE "
"FALSE "

TABLE 6-7. QUERY COMMAND DESCRIPTIONS

ERROR	ERR	- The current error status of the instrument
SETTINGS	SET	- The current operating status of the instrument
HELP	HLP	- The customer service phone number
IDENTIFY	ID	- The manufacturer, model number, and revision level
OPTIONS	OPT	- The current options installed
AUTO FREQUENCY CAL	AFC	- Perform an auto frequency calibration
KEY	KEY	- Read a front panel key
FREQUENCY	FRQ	- The current frequency setting
LEVEL	LVL	- The current level setting
INTERNAL AM	IAM	- The current internal am setting
INTERNAL FM	IFM	- The current internal fm setting
EXTERNAL AM	XAM	- The current external am setting
EXTERNAL FM	XFM	- The current external fm setting
EXTERNAL PHASE MOD	XPH	- The current external phase mod setting
MOD RATE	RTE	- The current mod rate setting
DUTY CYCLE	DTY	- The current int pulse mod duty cycle setting
STEP SIZE	STP	- The current frequency step size setting
STORE	STR	- The last memory location stored
RECALL	RCL	- The last memory location recalled
CURSOR POSITION	POS	- The current cursor position & display data
RF POWER	RF	- The RF off/on status
EXTERNAL PULSE MOD	XPL	- The external pulse mod status
INTERNAL PULSE MOD	IPL	- The internal pulse mod status
REQUEST FOR SERVICE	RQS	- The service request enable/disable status
MODULATION	MOD	- The current modulation sources selected
DEFINE DEVICE TRIG	DDT	- The contents of the group execute trigger buffer
CALIBRATION	CAL	- The current calibration data
TEST	TST	- Various diagnostic test results
IF	IF	- A true/false indication of the last IF command executed

TABLE 6-8. NUMERIC AND STATUS QUERY COMMAND RESPONSES

FRQ	"	FREQUENCY xxxx.xxxxxxx MHz	"	
LVL	-	"AMPLITUDE xxxx mV	"	
IAM	-	"INTERNAL AM xx.x %	"	
IFM	-	"INTERNAL FM xx.x kHz	"	
XAM	-	"EXTERNAL AM xx.x %	"	
XFM	-	"EXTERNAL FM xx.x kHz	"	
XPH	-	"EXT PHASE xx.xx rad	"	if phase mod installed
RTE	-	"MOD RATE x.xxx kHz	"	
DTY	-	"DUTY CYCLE xxx %	"	if int pulse mod installed
STP	-	"FREQ STEP xxxx.xxxxxxx MHz	"	
STR	-	"STORE xx	"	
RCL	-	"RECALL xx	"	
POS	-	"pp ccccccccccccccccccccccccc	"	if extended GPIB enabled
RQS	-	"RQS OFF	"	
		"RQS ON	"	
RF	-	"RF OUTPUT OFF	"	
		"RF OUTPUT ON	"	
XPL	-	"EXT PULSE OFF	"	if ext pulse mod installed
		"EXT PULSE ON	"	
IPL	-	"INT PULSE OFF	"	if int pulse mod installed
		"INT PULSE ON	"	
MOD	-	"MOD OFF	"	
		"INT AM	"	
		"INT FM	"	
		"EXT AM	"	
		"EXT FM	"	
		"INT AM/EXT FM	"	
		"INT FM/EXT AM	"	
		"MODULATION POS MET	"	
		"MODULATION NEG MET	"	
		"EXT PHM	"	if phase mod installed
		"INT AM/EXT PHM	"	" " " "
		"EXT PM	"	if ext pulse mod installed
		"INT AM/EXT PM	"	" " " " "
		"INT FM/EXT PM	"	" " " " "
		"EXT AM-PM	"	" " " " "
		"EXT FM-PM	"	" " " " "
		"INT AM/EXT FM-PM	"	" " " " "
		"INT FM/EXT AM-PM	"	" " " " "
		"EXT PHM-PM	"	if ext pulse & phase installed
		"INT AM/EXT PHM-PM	"	" " " " "
		"INT PM	"	if int pulse mod installed
		"INT AM-PM	"	" " " " "
		"INT FM-PM	"	" " " " "
		"INT PM/EXT AM	"	" " " " "
		"INT PM/EXT FM	"	" " " " "
		"INT AM-PM/EXT FM	"	" " " " "
		"INT FM-PM/EXT AM	"	" " " " "
		"INT PM/EXT PHM	"	if int pulse & phase installed
		"INT AM-PM/EXT PHM	"	" " " " "

TABLE 6-9. ERROR QUERY COMMAND RESPONSES

POWERUP ERRORS -

"001-SYSTEM HARDWARE FAILURE"	Indicates that one or more of the powerup diagnostic tests has failed. A more specific error indication can be determined by executing the TST 0? command to run autodiagnostics.
"010-CALIBRATION DATA ERROR "	Indicates that the checksum of the calibration tables didn't match what was stored in RAM. This can be caused by writing to the cal tables with the TST command or if the non-volatile RAM is failing. The default cal tables are not loaded automatically if this occurs, so that the old data can be examined for the error.
"011-OPTION DATA ERROR"	Indicates that the checksum of the option data didn't match the checksum stored in RAM. This can be caused by writing to the option table with the TST command or if the non-volatile RAM is failing. The default option selections are automatically loaded.
"012-POWERUP SETTINGS ERROR"	Indicates that the checksum of the instrument settings data didn't match the checksum stored in RAM. This can be caused by writing to the instrument settings table with the TST command or if the non-olatile RAM is failing. The default settings are automatically loaded.

COMMAND EXECUTION ERRORS -

"101-INVALID COMMAND HEADER"	Indicates that the header part of the command was not found. Either the minimum or maximum command string requirements was not met.
"102-INVALID COMMAND ARGUMENT"	Indicates that an illegal command argument was used, or an illegal character was found after the command header.
"103-COMMAND ARGUMENT MISSING"	Indicates a command header that required an argument was used without one. Only direct commands defined in sect 6.3.4.4 can be used without an argument.
"105-ARGUMENT OUT OF RANGE"	Indicates one of the numeric commands was issued with an argument value that exceeded its range. Valid range limits are listed for all of the numeric commands in Table 6-3.
"106-FM LIMITED IN DIVIDER BAND"	Indicates the frequency was set to a value in the range from 137.5 to 275 MHz (divider band) while the FM deviation was greater than 500 kHz. The frequency executes correctly, but the FM is set to its maximum value of 500 kHz.
"110-OPTION NOT INSTALLED"	Indicates that a command that requires an option was used and the option is not currently installed in the unit.
"120-INVALID STORED SETTING"	Indicates that a recall command was performed for a stored setting location that does not contain valid data. The instrument settings parameters remain unchanged.
"130-PRIVILEGED COMMAND"	Indicates that an extended GPIB command was used when the extended features was not enabled. See section 6.3.7.

TABLE 6-9. ERROR QUERY COMMAND RESPONSES (Con't)

"131-INVALID DIAGNOSTIC COMMAND"	Indicates that the TST command was used with an illegal test command specifier.
"132-UNDEFINED QUERY COMMAND"	Indicates that the command header specified was a valid command, but was not defined as a query command (e.g. LLO? is an undefined query).
"140-GET BUFFER OVERFLOW"	Indicates that the DDT command list exceeded the range of the GET (group execute trigger) buffer. The DDT command is executed, but any commands that don't fit completely in the buffer are excluded. Use the DDT? command to verify the DDT command list. Note that the buffer is 512 characters long. If this limit is exceeded, try using the shortest form of the commands that are allowed (e.g. use FRQ 123 Mz instead of FREQUENCY 123.000 MHz).
"150-INVALID CAL TABLE SELECT"	Indicates that the CAL command was executed with an invalid cal table code. The code is the 2 alpha characters that immediately follows "CAL ". There are currently 8 cal table codes: LD, LF, LC, LL, FD, FL, FC, FM. Note that the command CAL 0 does not use a cal table code.
"151-INVALID CAL TABLE OFFSET"	Indicates that the CAL command was executed with an invalid character in the offset value. The offset value is the 3 hexadecimal digits following the cal table code. These characters must be in the range 0-9 or A-F, and there must not be any spaces between the cal table code and this offset value. Spaces may precede the cal table code and follow the offset value.
"152-INVALID CAL TABLE FORMAT"	Indicates that the CAL LD, FD, or LF command was executed with invalid data. The data for the LD and FD tables must be BCD digits (0-9), and the LF command requires that the 3 least significant digits of the 2-byte entries must be BCD and the most significant digit must be a hexadecimal value between 5 and A, inclusive.
"153-CAL TABLE OFFSET OVERFLOW"	Indicates that the CAL command was executed with an offset value that exceeded the size of the selected table. Each table has a size associated with it. These are: LD=002, LC=CFF, LF=0FF, LL=015, FD=002, FC=01B, FL=01B, FM=113. These are the maximum offset values for the tables. The LC and LF tables, however, may have lower values depending on how many level flatness calibration points are currently defined. See section 6.3.6 for more information.
"180-QUERY ARGUMENT NOT FOUND"	Indicates that a valid query command was given, but the response message was not able to be completed. This indicates that a system error has occurred. Please report this condition to our customer service department, along with any information about the commands that were sent prior to this error.
"181-COMMAND BUFFER OVERFLOW"	Indicates that the argument in the command string entered exceeded the maximum length of 27 characters. This maximum argument length is for the numeric portion only, and does not include the header, units, or separator characters.

TABLE 6-9. ERROR QUERY COMMAND RESPONSES (Con't)

"199-UNDEFINED EXECUTION ERROR"	Indicates that an undefined error condition exists. Please report this condition to our customer service department, along with any information about the commands that were sent prior to this error.

HARDWARE ERRORS -

"200-LO UNLOCKED	"	- see UNLOCK2 in Sect 3.6.1
"201-SYNTHESIZER UNLOCKED	"	- see UNLOCK1 in Sect 3.6.1
"202-UNIT UNLEVELED	"	- see UNLEVEL in Sect 3.6.1
"203-CIRCUIT BREAKER TRIPPED	"	- see TRIP in Sect 3.6.1
"205-MOD FREQ REF ERROR	"	- see MODFREQ in Sect 3.6.1
"206-REF SYNTHESIZER UNLOCKED	"	- see UNLOCK3 in Sect 3.6.1
"230-CONTROL uP FAILURE	"	- see description in Sect 3.6.1

NO ERROR -

"499-SYSTEM OPERATIONAL	"	Indicates no error conditions currently exist

6.3.4.6 SPECIAL COMMANDS

The special commands are listed in Table 6-10 along with a brief description of their function. These commands are classified as "special" because they do not have a standard form for their arguments. Each of them will be discussed in
detail in this section, and their command format will also be described.

The TRM command allows the user to change the programmable terminator character of the instrument. This terminator character will then be used to terminate a message from the GPIB. The carriage return (CR) and linefeed (LF) characters, as well as the issuance of an EOI will always cause a termination regardless of what the terminator character is set to. Output messages, however, always use the programmable terminator character combined with the EOI to terminate all messages. The programmable terminator character may be set to any ASCII control character. The control characters have data values ranging from 0 to 31 decimal (00 to 1F hex). The TRM command can be issued in either of 2 forms:

TRM sp <ASCII character> ;
or TRM sp <decimal code> ;

First note that in both cases a semicolon terminator character should be placed at the end of the command to assure that the command is terminated correctly. This is due to the fact that the programmable terminator character is not modified until the command has been executed. The first form of the command requires that the terminator character itself be output. Often, this can be difficult to send out a control character in a command string. The second form of the command can easily be sent out, since the argument consists of an ASCII-formatted decimal string. The string consists of 2 BCD digits (0-9) that form the decimal value of the selected control character. As an example, if the terminator character is to be set to a carriage return character (decimal value 13), the following 2 commands would be perform the same task:

TRM <Ctrl-M>;
TRM 13;

Where <Ctrl-M> represents the carriage return character, equivalent to holding down the "CTRL" key while pressing the "M" key on a standard ASCII keyboard. In a BASIC program, CHR$(13) can usually be used to generate this value.

The DDT command defines the commands to be executed when a group execute trigger command (GET) is received. The DDT command can be used in 3 different modes: direct, query, and special. The first 2 modes are discussed in other sections, and perform a reset and buffer data request, respectively. The special form of the command has the following format:

DDT { <command string> ; } !

Where <command string> consists of any 2405/2410A GPIB command string and the { } indicates that several of these commands can be strung together, separated by either the semicolon command separator or a terminator character. The command must always end in an exclamation mark. This character indicates to the

2405/2410A that the DDT command has ended, and to resume normal processing of the input commands. While in the DDT definition process, none of the commands are executed, but are placed into the GET buffer, for execution at a later time by the GET command. For economy of buffer space, the shortest form of the command strings are recommended. Since the buffer is limited to 512 characters in length, the length of the command strings will determine the number of messages that can be stored. The DDT command will be aborted if an error is detected in one of the commands defined, or if one of the commands is the DCL command. The DCL command will reset the GET buffer to the empty state, whereas an error will save all of the commands received up to and including the error. Only command syntax errors will be detected during the DDT command, since value checking is not performed until execution (e.g. an out of range value will not be flagged as an error during this command). This command will be discussed in more detail in section 6.3.8.

The CAL command is used for modifying the contents of the calibration tables. There are 6 calibration tables that can be modified, as well as the modification dates for level and frequency calibration. Another form of this command can be used to load the factory default calibration values. This command format is:

CAL sp 0;

The level flatness and linearity correction values are set to 0, level flatness calibration frequencies are set the factory settings, and the frequency calibration tables are set to generic settings. The level and frequency calibration dates are set to 00-00-00.

The other form of the command specifies one of the calibration tables (or dates), an offset to a particular entry in that table, and the data to set that entry (and the consecutive entries) to. The format for this is:

CAL sp LD000 sp <data string> ;

Where LD is one of eight different table select codes and 000 is the entry offset into that table. The data string consists of groups of 2 ASCII-hex characters (0-9 and A-F) that represent the data byte values to output. There cannot be any spaces contained in the data string, and there must be an even number of digits (characters). If a space is inserted in the data string, a command header error (101) will be indicated. The table select codes and allowable offset values will be explained in section 6.3.6.

The TST special command is used to set latches, dac values, and memory contents. The argument of this command contains information that specifies the latch, dac, or memory address, as well as the data to output. This command requires the extended GPIB diagnostics to be enabled, and is explained in more detail in section 6.3.7.

The IF command is used to test how a selected numeric parameter compares to a specific value. An internal flag is set indicating the result of the comparison, so that a THEN or an ELSE command can react accordingly. The IF? command also makes use of the internal flag by outputting a message indicating the result of the comparison. The format of the command is:

IF sp <header> sp [<comparator> sp] <numeric argument> ;

The comparator characters <, >, = may be used in any combination, or omitted entirely from the command. If no comparator is given, an equality (=) is assumed. Combinations of symbols indicates an OR of the symbols. That is, >= can be used to represent "greater than or equal to", <= can be used to represent "less than or equal to", and <> can be used to represent "not equal to". If the value of the parameter associated with the header compares correctly with the numeric argument, the internal flag will be assigned the value TRUE, else it is assigned the value FALSE. For example, if the current frequency value is set to 123.4 MHz, the following flag assignments will be made for these statements:

IF FRQ < 500 MHz;	TRUE
IF FRQ = 123.4 MHz;	TRUE
IF FRQ <> 222 MHz;	TRUE
IF FRQ >= 400 MHz;	FALSE

The headers that are valid are: FRQ, LVL, IAM, IFM, XAM, XFM, XPH, STP, RTE (only if VAR option installed), TST (if extended GPIB diagnostics enabled). The IF TST command only works on tests 2-6 (the 1st digit of the argument), and the argument is formatted the same as for the query command, with the data value to compare to appended to the end. The comparisons are performed on a byte by byte basis and unsigned binary values are assumed. See section 6.3.7 for more information on the diagnostic tests.

The THEN command is used to conditionally execute the following command, based on the status of the internal flag set by the IF special command. If the flag is TRUE, the command will execute, if not no action will be taken. This looks like any other command with "THEN " preceding it. Any command may be used with this command other than IF, THEN, ELSE, DDT, or DCL.

The ELSE command is used to conditionally execute the following command, based on the status of the internal flag set by the IF special command. If the flag is FALSE, the command will execute, if not no action will be taken. This looks like any other command with "ELSE " preceding it. Any command may be used with this command other than IF, THEN, ELSE, DDT, or DCL.

The DISP special command is used to put text characters on the LCD display. The characters following "DISP" will be placed on the display starting at the current cursor position (set by the POS command). The cursor position is then incriminated to the location following the last position written. Positions 0 through 39 are the top row characters from left to right, and 40 to 79 are the bottom row. The cursor wraps from location 79 to position 0. Due to the fact that leading space characters will be assumed to be command separator characters and will be ignored, using the ASCII ~ character as the 1st character in the argument will be replaced by a leading space. Spaces can be used normally after this character. The special character set may be obtained by setting the 1st character of the string to an ASCII | character. More details are available on this command in the diagnostics manual, since this command should not normally be needed by the user. The extended GPIB diagnostics mode must be enabled for this command to function.

TABLE 6-10. SPECIAL COMMAND DESCRIPTIONS

TERMINATORS	TRM	- set the programmable terminator character
DEFINEDEVICETRIG	DDT	- save commands into the GET buffer
CALIBRATION	CAL	- modify the calibration table data
TEST	TST	- perform various diagnostic tests
IF	IF	- set an internal flag based on a comparison of a numeric parameter or diagnostic result to a specified value
THEN	THEN	- execute the following command only if the last IF command comparison was true
ELSE	ELSE	- execute the following command only if the last IF command comparison was false
DISPLAY	DISP	- output a string of characters to the LCD display

6.3.5 READING RESPONSES AND THE SERIAL POLL REGISTER

Response messages to be read by the controller are generated only by a query command, and all query commands generate at least one response message. These messages are placed in a buffer for reading by the controller when it generates a response request. The message buffer is 16 messages deep, and always holds only the most recent messages. This infers that if query responses are not read promptly, they will be overwritten. The only responses that behave differently are for CAL, DDT, and KEY queries. The CAL and DDT responses have the potential for being more than 16 messages in length, therefore do not overwrite the older information, and the KEY query waits for a front panel keypress before responding. If these special query commands cannot be completed immediately (i.e. the buffer becomes full or waiting for a key input) all other query commands issued will be ignored. As soon as the pending response is completed, the query commands will be re-enabled.

For example, if the command string CAL?; RF ON; ERR? is given, the calibration messages will fill the output buffer, and will require the controller to read these messages so that it can complete the response by overwriting the messages read. With the output buffer filled, this command is temporarily completed until some buffer space is freed, so the next command is processed. The next command turns the RF output on. This command can be executed because it does not return a response to the buffer. The last command is another query and therefore cannot be executed due to the buffer full condition. This command is not postponed until the buffer is available, it is ignored entirely. Because of this, it is advised that no query commands be executed if there is currently a query message pending. This "message pending" status can be determined from the serial poll register, described next.

In order to know when there are messages in the buffer, whether an error has occurred, and other status conditions, the serial poll register may be read independently from the message output buffer. This is a 1-byte (8-bit) value that contains information essential for reading from the output buffer. Each bit of this register is defined as follows:

Bit 7: (reserved)
Bit 6: SERVICE REQUEST
Bit 5: Error condition
Bit 4: Message available
Bit 3: (undefined)
Bit 2: (undefined)
Bit 1: Output buffer empty
Bit 0: Output message busy

The service request flag (bit 6) is set to a 1 only if service requests have been enabled (from the front panel SRQ keystroke, or the RQS ON GPIB command) and either an error condition exists or a message is available. This bit also causes the SRQ line on the GPIB bus to be asserted if set to a 1. If the controller is set up to respond to service requests, this can cause an interrupt to the controller so that it can take the appropriate action without affecting its normal "background" processing.

The error condition flag (bit 5) is set to a 1 whenever an error occurs. This can be a powerup error, a hardware error condition, or a command execution error. This flag is cleared when the error condition is read by sending the ERR? query command and reading the response.

The message available flag (bit 4) is set to a 1 whenever a message is placed in the GPIB output buffer, and is ready to be read by the controller. If a message is attempted to be read when there are no messages in the buffer (when this flag is 0) a null message is returned that consists of a terminator character only. When all of the messages have been read, this flag will be reset to 0.

The output buffer empty flag (bit 1) is set to a 1 when there are no messages in the output buffer, and set to a 1 when it is empty. It is identical to the message available flag, except it has opposite logic.

The output message busy flag (bit 0) is set to a 1 when a query command has been issued and its has not yet been completed. It is reset to a 0 when the message has been completed. This flag is used for multi-message query responses such as the CAL?, to indicate that the response has not been completed even if the message available flag indicates that the output buffer is currently empty. This can be used to prevent incomplete messages from being read, as well as preventing query commands from being issued while a prior query command has not yet been completed.

6.3.6 CALIBRATION COMMANDS

The four types of CAL (Calibration Commands) are:

"AFC ?"
"CAL 0"
"CAL ?"
"CAL + data string"

"AFC ?" will cause the unit to perform an automatic frequency calibration. The calibration will take 8-12 minutes after which an AFC passed or AFC failed message will be generated. The "message in process" flag in the serial poll register is set while the calibration is executing and cleared when it is completed. No other commands can be executed until completion once this command is issued.

"CAL 0" is used to load the factory default calibration values into the calibration tables. "CAL ?" is the CAL QUERY, the request for all calibration data. The level and frequency calibration data will be returned as a series of data strings. "CAL + data string" sends change information for specific calibration data as identified and coded in the data string.

The data strings shown after a "CAL ?" query or the data string used with a "CAL + data string" entry have the same character definition. A typical string sequence following the "CAL ?" entry might contain lines that look like the following (the dotted lines indicate the entire sequence of data strings is not shown):

```
LF000 5100520053005400550056 00
LF006 5700580059006100620063 00
LF00C 6400650066006700680069 00
  ... ... ... ... ... ... ...
LC000 0001FEFC0406000003020202
LC00C 020000000004040000000001
  ... ... ... ... ... ... ...
FL000 4040404040404040404040
FL00C 404040404040
  ... ... ... ... ... ... ...
FC 000 324549505357595C666A7177
FC00C 82868F939
  ... ... ... ... ... ... ...
FM000 055505550555055055505555
FM006 05550555055505550550555
  ... ... ... ... ... ... ...
FM10E 055505550555055055505555
```

As indicated above, not all 30 character spaces may be needed in each data string.
A typical data string sent with the "CAL + data string" entry might be:

"CAL LF000 5100520053005400550056 00"

The level calibration and frequency calibration date entries produce strings with slightly different formats. They are single line entries of format:

"LD000 MMDDYY"
"FD0000 MMDDYY"

The characters MMDDYY are replaced by decimal digits representing the date last set.

The argument (characters following CAL) for the preceding entry and the characters in the data strings resulting from a "CAL?" entry have identical definitions. Characters 1-2 are the table selections alpha code. The code, listed in the order in which information is supplied following a "CAL ?" query, is:

LD = the level calibration date.

LF = the level calibration frequency table, which contains the frequencies at which level calibration is to be performed.

LC = the level flatness calibration correction table, which contains the level correction in .1 dB increments at each calibration point.

LL = the level linearity calibration correction table, which contains the corrections at 1 dB decrements from +13 dBm to -7 dBm. Plus the attenuator trip point in .1 dBm units (+3.1 to -7.0 dBm).

FD = the frequency calibration date.

FL = the frequency loop compensation DAC table, which contains DAC compensation values for frequencies starting at 275 MHz, with each succeeding entry at a 10 MHz higher frequency.

FC = the frequency coarse DAC table, which contains coarse DAC values for frequencies starting at 275 MHz, with each succeeding entry at a 10 MHz higher frequency.

FM = The FM calibration table, which contains FM values starting at 275 MHz, with each succeeding entry at a 1 MHz higher frequency.

The following descriptions apply to the formats for the calibration tables (LF, LC, FL, FC, FM, and LL) listed above. The calibration date formats have been described earlier in this section.

Characters 3-5 indicate the entry number of the selected table at which to store the calibration data. Table entry lengths can be one or two bytes. The first byte of each table is "000", with the exception of the level calibration table (LC). The first digit of the LC first byte indicates the attenuator selection (range 0-C; hex for 12, or 120 dB). The last two digits indicate the level calibration entry number for that attenuator.

Character 6 is a data field separator (an ASCII space character).

Characters 7 to the end of the string contains the actual data, which is described in detail in the following sections.

Each byte of data is represented as 2 ASCII characters. In the following descriptions, a data value that has a "signed binary byte" is data that has its two ASCII characters converted into the binary value they represent. The ASCII "E2", for example, would be converted into their hexadecimal value $E2 (a one byte binary value). Therefore, all data characters must be made up of ASCII characters 0-9 and A-F (lower case accepted), unless the data is decimal. If the data is decimal, only the characters 0-9 are allowed.

Each of the level frequency (LF) table data entries are four characters in length. These entries represent the frequencies at which the level calibration data values (LC) are to be used. The number of entries in this table can be increased from the 42 set up in default to a maximum of 255. The range of valid frequencies is from 10 kHz to 1100 MHz, the operating range of the instrument. The format of the date entry is:

char 1 = exponent of frequency value in .1 Hz units; range from 5 to 9; for example, 10 kHz would be E5 (10 kHz in Hz units is E4, but exponent must increase by 1 when using .1 Hz units = E5)

char 2 = most significant digit of frequency data; must be a nonzero decimal value

char 3 = second most significant digit of frequency data; must be a decimal value

char 4 = third most significant digit of frequency data; must be a decimal value

Each of the level correction (LC) table data entries are two characters in length. These entries represent the level correction values (factors) in .1 dB units to be applied at their corresponding level calibration frequencies. The calibration data is in signed binary notation. A correction value of "FE", for example, corresponds to a correction of -0.2 dB. A value of "12" corresponds to a correction of +1.8 dB. Level calibration values are interpolated between the level frequency (LF) table entries.

The number of entries in the LC table must always be the same as the number of entries in the LF table. Therefore, if the LC table is to be extended, the additional frequencies must first be defined in the LF table.

Each of the loop compensation DAC (FL) table data entries are two characters in length. These entries represent the values to be programmed into the loop compensation DAC for the given frequencies. The number of entries in this table is fixed at 28. This corresponds to one entry every 10 MHz, starting at 275 MHz. The values are one byte binary, with a range from 00 to FF.

Each of the coarse tune DAC (FC) table data entries also are two characters in length. These entries represent the values to be programmed into the coarse tune DAC for the given frequencies. The number of entries in this table also is fixed at 28. This corresponds to one entry every 10 MHz, starting at 275 MHz. The values are one byte binary, with a range from 00 to FF.

Each of the FM calibration (FM) table data entries are four characters in length. These entries represent the FM DAC values corresponding to a deviation of 1 MHz at the given frequencies. The number of entries in this table is fixed at 276. This corresponds to one entry every 1 MHz, starting at 275 MHz. The values are twelve bit binary, with a range from 0000 to 0FFF (the first character always must be "0").

The level linearity (LL) calibration table entry produces a 22-byte long string, each byte represented by 2 hexadecimal characters. Because each line displays 12 bytes, the data is shown on 2 lines and is organized as follows. The first byte represents the level linearity correction at +13 dBm. Succeeding values represent corrections at 1 dB decrements up to and including -7 dBm. Correction factor limits are the same as those for the level flatness (LC) data. Those limits are from -60 to +60, (hexadecimal values C4 to FF for negative values and 00 to 3C for positive values). The last (22nd) byte represents the point at which the attenuator is set to trip. This can be varied over the range +3.1 to -7.0 dBm. The attenuator will change settings when the output level value drops below this value, and every 10 dB step below this value. The value is in the same format as the level flatness (LC) data. This value can be adjusted when trying to avoid an attenuator trip over a limited range. The default trip point is -3.0 dBm.

If the data string length exceeds 12 data bytes (24 characters), no error is generated but the string is truncated to 12 bytes.

If the data string length is less than 12 data bytes (24 characters), no error is indicated and only those data bytes read are output.

6.3.7 DIAGNOSTICS AND EXTENDED GPIB COMMANDS

Board level testing (remote operation of the auto-diagnostics, executing a selected auto-diagnostic test, reading from and writing to selected latch or DAC devices, reading any selected A/D testpoint, and reading/writing to memory) may be accomplished across the GPIB. A password (supplied separate to this manual for security purposes) is required to access these commands.

The unit powers up with the extended mode disabled. It may be enabled from the front panel in Local operation or across the GPIB. Press the "Stat" key to call up the STATUS menu. Press the RF on/off key from the Status menu to call up the password prompt display:

——current unit status————————
Enter password

When the proper password has been entered, the extended GPIB features will be enabled and a message that they are enabled will be displayed:

GPIB Extended Command Mode
ENABLED

The password characters are not displayed on the screen. If an erroneous password is entered, the first key detected that is not in the given sequence will abort the password entry mode and return to the STATUS menu to the display. To re-enter the password, press the RF ON/OFF key and try again.

The Status menu display must be exited before further request will be handled.

There are two types of test commands. Test Set commands set the data of a given memory location, latch, or DAC. Test Query commands request data information. Only test query commands will return a response message.

The test set commands are:

TST 1cldd -	write data "dd" to card # "c" latch # "l"
TST 2nvvv -	write data "vvv" to dac # "n"
TST 5aaaadd -	write data "dd" to control microprocessor address "aaaa"
TST 6aaaadd -	write data "dd" to control microprocessor address "aaaa"

TST 75aaaa - Increment data at communication microprocessor address "aaaa"

TST 76aaaa - Increment data at control micropro cessor address "aaaa"

TST 85aaaa - Decrement data at communication microprocessor address "aaaa"

TST 86aaaa - Decrement data at control micropro cessor address "aaaa"

The test query commands are:

TST 0 ? - perform complete AutoCalÒ test and return results

TST 0xx ? - perform AutoCalÒ test # "xx" and re turn result

TST 1cl00 ? - request data value of card # "c" latch # "l"

TST 2n000 ? - request data value of dac # "n"

TST 300tt ? - request + peak a/d value of testpoint # "tt"

TST 400 tt ? - request - peak a/d value of testpoint # "tt"

TST 5aaaa ? - request communication microproces-sor data value at address "aaaa"

TST 6aaaa ? - request control microprocessor data value at address "aaaa"

The ranges for the variables listed above are:

"aaaa" address range = 0000 to ffff

"dd" data range = 00 to ff

"c" card number range = 0 to 9

"l" latch number range = 0 to f

"vvv" dac value range = 000 to fff for 12 bit DACs'

"vvv" dac value range = 000 to 0ff for 8 bit DAC's

"n" dac number range = 0 to b (see Table 6-11, DAC Test Table)

"tt" testpoint number range = 00 to 10 (See Table 6-12, ADC Test Table)

"xx" AutoCalÒ test number range = 00 to 0d (See Table 6-13, Autotest Table)

Table 6-11 DAC TEST TABLE

"n"	DESCRIPTION	BITS
0	Ramp all DACs	N/A
1	AM depth DAC	12
2	FM deviation DAC	12
3	Level DAC	12
4	Coarse tune DAC	8
5	Loop comp DAC	8
6	A aux pll reg	8
7	N aux pll reg	8
8	R aux pll reg	8
9	A main pll reg	8
A	N main pll reg	8
B	R main pll reg	8

Table 6-10 ADC TEST TABLE

"tt"	TEST POINT
00	0.0 v (Ground ref)
01	+10 V ref
02	AM DAC output
03	FM DAC output
04	Level DAC output
05	Temp sensor
06	Ext analog input
07	Syn: error voltage
08	Syn: tuning voltage
09	Dbl: loop error
0A	Dbl: loop control
0B	AM: testpt 1
0C	AM: testpt 2
0D	AM: testpt 3
0E	Out amp: detect test
0F	Out amp: PIN test
10	Rev: VCO tuning

Table 6-13. AUTOTEST TABLE

"xx"	TEST SELECTED
00	Control Microprocessor
01	Communications Microprocessor
02	Non-volatile RAM
03	Dual Port RAM
04	Static RAM
05	Control ROM
06	Communication ROM
07	RF Data/Address Bus
08	Card ID Code
09	ADC/DAC
0A	LO Unlocked Feedback
0B	Synthesizer Unlocked Feedback
0C	Carrier Unleveled Feedback
0D	Mod Reference Feedback

Two error message responses are unique to the GPIB diagnostic commands. In both cases, the error is indicated by the setting of the error bit (bit 5) in the serial poll register. The error messages will be output by issuing the error query command "ERR ?". If the extended GPIB command mode has not been enabled as described earlier, and one of the diagnostic commands is executed, the following response will be generated when the "ERR?" command is issued:

"130 PRIVILEGED COMMAND"
If an invalid diagnostic command is sent, or the GPIB extended command mode password command is sent when the extended mode is already enabled, the following response will be generated when the "ERR ?" command is issued:

"131 INVALID DIAGNOSTIC COMMAND"
All of the diagnostic execution commands execute without returning a response message. All of the diagnostic query commands respond with a message, 30 characters in length. The messages are in the following formats:

TST 0?: "ALL TESTS PASSED" if all tests passed "<test name> <code> if a test failed where "<test name> is the name of the failed test and "<code>" is the four character defining the error condition (see Section 8.18 and Table 8-5).

TST 0xx?: "<test name> PASS" if the selected test passed "<test name> <code> if the selected test failed where "<test name> is the name of the failed test and <code> is the four character code defining the error condition (see Section 8.18 and Table 8-5 for detailed information).

TST 1c100 ?: "dddd"
TST 2n000 ?: "dddd"
where "dddd" is the selected latch of dac value in 2-byte hex format.

TST 300tt ?: "svvv"
TST 400tt ?: "svvv"
where "s" is the sign of the voltage (+ or -) and "vvv" is the a/d voltage at the selected testpoint in 0.01 v units (bcd format).

TST 5aaaa ?: "COMM aaaa:<hex data string>"
where "aaaa" is the start address specified in the command and <hex data string> is 10 bytes of data in hex format that are read from the specified starting address.

TST 6aaaa ?: "CTRL aaaa:<hex data string>"
where "aaaa" is the start address specified in the command and "<hex data string>" is 10 bytes of data in hex format that are read from the specified starting address.

Several sample commands and their possible response are shown in the following section.

The command "TST 0?" requests the unit perform a complete auto diagnostics test. The typical response is "ALL TESTS PASSED" after all tests have been completed.

The command "TST 009 ?" requests the unit perform auto diagnostics test number 9. A typical failed response is "ADC/DAC 0030", indicating the ADC/DAC test had failed because of a high range and low range failure.

The command "TST 12345 ?" instructs the unit to write hex 45 to latch 3 of card 2 (RF data out latch of the Control Card). There will be no response to this command.

The command "TST 10300 ?" instructs the unit to read latch 3 of card 0 (100 kHz/10 kHz prog the DDS card). The response would be "0043", the data in latch 3 of this card.

The command "TST 30004 ?" instructs the unit to read testpoint 4 (the Level DAC output) with positive peak detection. The response would be "0126", the Level DAC output of +1.26 v.

6.3.9 SAMPLE SOFTWARE PROGRAMS

These basic programs can be adapted to any GPIB controller if the appropriate write and address formats are substituted. These programs illustrate the 2405/2410A as a listener. The 2405/2410A is also a talker.

PROGRAM FUNCTION: FREQUENCY

Exercise: Program the frequency in 50 MHz steps between 100 and 550 MHz.

WAVETEK 6000 BASIC:

```
100 FOR I=100 TO 550 STEP 50
110 WRITE @ 702:"FRQ "&STR$(I)& "MHZ;"
120 WAIT DELAY.2
130 NEXT I
140 END
```

The 200 millisecond time delay in line 120 permits the Model 2405/2410A frequency to stabilize.
HP85 BASIC:

```
100 FOR I=100 TO 550 STEP 50
110 OUTPUT 702;"FRQ "&VAL$(I)&"MHZ;"
120 WAIT 200
130 NEXT I
140 END
```

HP9825 HPL:

```
0: FOR I=100 TO 550 STEP 50
1: WRT 702,"FRQ "&STR(I)&"MHZ;"
2: WAIT 200
3: NEXT I
4: END
```

IBM PC BASIC:

```
100 FOT I=100 TO 550 STEP 50
110 I$=RIGHT$(STR$(I),LEN(STR$(I))-1)
120 WRT$="FRQ "+I$+"MHZ;"
130 CALL IBWRT(SIGEN%,WRT$)
140 FOR J=1 to 200
150 NEXT J
150 NEXT J
160 NEXT I
170 END
```

In line 110 a blank space is removed to prevent an illegal response. IN lines 140 and 150 an approximate delay is achieved by using a for-next 1000.

NOTE: The necessary program lines that initialize the PC, set the device number, and clear the 2405/2410A (NAME: SIGEN) are omitted from the above program.

PROGRAM FUNCTION: LEVEL

Program the output level in 5 dB steps between +10 and -100 dBm. Initially set the frequency to 500 MHz in CW mode with the RF on.

WAVETEK 6000 BASIC:

```
100 WRITE@702:"FRQ 500 MHz; MOD OFF; RF
    ON;"
110 WAIT DELAY .2
120 FOR I=10 to -100 STEP -5
130 WRITE!702:"LVL "&STR$(I)& "DBM;"
140 NEXT I
150 END
```

HP 85 BASIC:

```
100 OUTPUT 702:"FRQ 500MHz; MOD OFF; RF
    ON;"
110 WAIT 200
120 FOR I=10 TO -100 STEP -5
130 OUTPUT702;"LVL "&VAL$(I)&"DBM;"
140 NEXT I
150 END
```

HP 9825 HPL:

```
0:  WRT 702,"FRQ 500MHZ;MOD OFF;RF ON;"
1:  WAIT 200
2:  FOR I=10 TO -10 STEP -5
3:  WRT702,"LVL "&STR(I)&"DBM;"
4:  NEXT I
5:  END
```

IBM PC BASIC:

```
100 WRT$-"FRQ 500 MHz;MOD OFf;RF ON;"
110 FOR I=1 to 200
120 NEXT I
130 FOR I=10 to -10 STEP -5
140 I$=RIGHT$(STR$(I),LEN(STR$(I))-1
150 WRT$="LVL "+I$+"DBM;"
160 CALL IBWRT(SIGEN%,WRT$)
170 NEXT I
180 END
```

PROGRAM FUNCTION: RF LEVEL (ON/OFF)

Set the Model 2405/2410A to 500 MHz at +13 dBm in CW mode with the RF output off for 400 milliseconds, then on for 200 milliseconds, then off again.

WAVETEK 6000 BASIC:

```
100 WRITE@702:"FRQ 500 MHZ; MOD OFF; RF
    OFF
110 WAIT DELAY .4
120 WRITE@702:"RF ON;"
130 WAIT DELAY .2
140 WRITE@702:"RF OFF;"
150 END
```

HP 85 BASIC

```
100 OUTPUT 702:"FRQ 500MHZ; MODE OFF; RF
    OFF;"
110 WAIT 400
120 OUTPUT702;"RF ON;"
130 WAIT 200
140 OUTPUT702:"RF OFF;"
150 END
```

HP 9825 HPL:

```
0:  WRT702,"FRQ 500MHZ; MOD OFF; RF OFF;"
1:  WAIT 400
```

```
2:  WRT702,"RF ON;"
3:  WAIT 200
4:  WRT702,"RF OFF;"
5:  END
```

IBM PC BASIC:

```
100 WRT$="FRQ 500MHZ; MOD OFF; RF OFF;"
110 CALL IBWRT(SIGEN%,WRT$)
120 FOR I=1 to 400
130 NEXT I
140 WRT$="RF ON;":CALL IBWRT (SIGEN%,WRT$)
150 FOR I=1 to 200
160 NEXT I
170 WRT$="RFOFF;":CALL IBWRT
(SIGEN%,WRT$)
180 END
```

PROGRAM FUNCTION: INTERNAL FM

Initially set the Model 2405/2410A to 500 MHz at +10 dBm in CW mode with RF output on. After 1 second, set the internal FM deviation to 500 kHz at 1 kHz modulation rate. After 500 milli-seconds turn the modulation off.

WAVETEK 6000 BASIC:

```
100 WRITE@702:"FRQ 500MHZ;LVL 10DBM ; MOD
    OFF;RF ON;"
110 WAIT 1
120 WRITE@702:"IFM 500KHZ;RTE 1000;"
130 WAIT .5
140 WRITE@702:"MOD OFF;"
150 END
```

HP 85 BASIC:

```
100 OUTPUT 702;"FRQ 500MHZ; RF ON;"
110 WAIT 1000
120 OUTPUT 702;"IFM 500KHZ; RTE 1000;"
130 WAIT 500
140 OUTPUT702;"MOD OFF;"
150 END
```

HP 9825 HPL:

```
0:  WRT702,"FRQ 500MHZ;LVL 10DBM; MOD OFF;
    RF ON;"
1:  WAIT 1000
2:  WRT702,"IFM 500KHZ; RTE 1000;"
3:  WAIT 500
4:  WRT702,"MOD OFF;"
5:  END
```

IBM PC BASIC:

```
100 WRT$="FRQ 500MHZ; LVL 10DBM; MOD OFF;
    RF OFF;"
110 CALL IBWRT(SIGEN%,WRT$)
120 FOR I=1 to 1000
130 NEXT I
140 WRT$="IFM 500KHZ; RTE 1000;"
150 CALL IBWRT(SIGEN%,WRT$)
160 FOR I=1 TO 500
170 NEXT I
180 WRT$="MOD  OFF;"
190 CALL IBWRT(SIGEN%,WRT$)
200 END
```

SECTION 7
PRINCIPLES OF OPERATION

7.1 INTRODUCTION

This is the theory of operation for the 2405/2410A. This section begins with a general overview of the instrument circuitry (Section 7.2) and proceeds to a detailed description of each board used (Sections 7.3 to 7.15). Each circuit board is described in terms of the schematic(s) associated with it. Some have more than one schematic. An overview of each board will be presented, followed by more detailed circuit descriptions where appropriate.

Figure 7-1 (0013-20-0006) is an overall block diagram of the 2405/2410A circuitry. Figures 7-2 thru 7-9 are block diagrams of individual board assemblies. Figure 7-10 shows card cage location for the boards. The detailed theory of operation makes extensive references to the schematic diagrams (Figures 9-1 through 9-16) bound in Section 9, the reference drawing section, of this manual. Schematics and their associated parts layout diagram(s) are located together in Section 9. Other reference drawings are also located in Section 9.

7.2 GENERAL OVERVIEW

The overall block diagram for the Model 2405/2410A synthesized Signal Generator is shown in Figure 7-1. The "BD" abbreviation for Board will be used in this text. The internal/external reference switching circuitry is select logic that is contained on the LO/REF BD and determines whether the internal 10 MHz Temperature Compensated Crystal Oscillator (TCXO) source will be used as the frequency reference or an external 10 MHz source will be substituted. The 10 MHz reference is divided by 10 to generate 1 MHz reference signals to the phase detector on the LO/REF BD and to the Reference Synthesizer and Control Bds. The 10 MHz reference also is sent to the DDS BD.

The Narrow VCO on the LO/REF BD provides a 512 MHz output to the Mixer on the OUTPUT BD. The 512 MHz output from this loop also is fed to a divide-by-512 ÷ 512) circuit. The resultant 1 MHz signal (512 MHz ÷ 512 = 1 MHz) is applied to the phase detector to provide an error voltage to lock the loop output at 512 MHz. This signal is used at output frequencies below 137.5 MHz.

The Reference Synthesizer Bd uses the signal from the DDS Bd and the 1 MHZ Reference from the LO/Ref Bd to generate a reference signal for the main PLL on the RF Synthesizer Bd. The Reference Synthesizer output frequency resolution is .1 Hz. This provides the fine unit output frequency resolution.

The Wide VCO loop on the RF SYNTH BD is the main loop for frequency synthesis. It contains two VCOs that provide outputs from 275 - 550 MHz to the DOUBLER BD.

The DOUBLER BD provides 275 - 1100 MHz outputs to the AM/DIV BD circuitry.

The main loop output frequency is the product of several operations. Software selects the appropriate VCO on the RF **SYNTH**. Software also provides the appropriate input to the coarse tuning circuitry to generate

an output frequency within tracking (lock-in) range of the loop. Frequency lock-in is controlled by the feedback circuit from the WVCO output to the phase detector in the WVCO loop. The output from the WVCO loop is fed to a divide-by-10 divider and then to the Main Loop Frequency Divider (Fractional-N Divider). The output of the divider is then fed to one input of the phase detector. The other phase detector input is connected to the reference synth output.

FM is added to the WVCO loop from the CONTROL BD.

The 275-550 MHz output from the RF SYNTH BD is fed to "straight through" (no frequency conversion) or to frequency doubler circuitry in the DOUBLER BD. One path provides direct coupling of the RF SYNTH BD output (275 - 500 MHz) to the AM/DIV BD. The other path connects the RF SYNTH BD output to the doubler circuitry. The RF SYNTH BD output will be doubled, applying 550 - 1100 MHz to the AM/DIV BD.

The 275-1100 MHz output from the DOUBLER BD is fed to "straight through" or divide-by-2 frequency conversion circuitry in the AM/DIV BD. The top path shown in the AM/DIV BD essentially provides direct coupling of the DOUBLER BD output (275 - 1100 MHz) to the amplifiers in the OUTPUT BD. The bottom path connects the DOUBLER output to the divide by two (÷ 2) circuitry. The 275-550 MHz output will be divided by two, applying 137.5 -275 MHz to the amplifiers in the OUTPUT BD.

The AM/DIV BD receives AM from the CONTROL BD as shown.

Both amplification and leveler circuitry are located on the OUTPUT BD on Figure 7-1. Outputs to the attenuator and to the Aux. output are shown.

The power output from the OUTPUT BD is applied to the Attenuator Assembly and its Reverse Power Protection circuitry before it is sent to the front panel RF OUT connector.

7.2.1 ON BOARD VOLTAGE REGULATION

The majority of the boards described in the following sections have on board voltage regulators. Voltage in and out is clearly identified.

7.2.2 IDENTIFICATION (ID) CODES

For debugging purposes, and to identify options installed and hardware revision levels, each card (except the μ P card) has a fixed 8-bit identification (ID) code that can be accessed by the μP card. ID codes are shown in Table 7-1.

TABLE 7-1 IDENTIFICATION CODES

	Function Hist Code	Position Code	Revision Code		
	D7 D6	D5 D4 D3	D2 D1 D0 :	Card Position :	Card Name
RF Cards:	0 0	0 0 1	0 0 1 :	4 :	RF Synthesizer
	0 0	1 1 0	0 0 0 :	5 :	Doubler
	0 0	0 1 1	0 0 0 :	6 :	AM/Divider
	0 0	1 0 0	0 0 0 :	7 :	Output Amp
	D7 D6	D5 D4 D3	D2 D1 D0 :	Card Position :	Card Name
	0 0	0 1 0	0 0 0 :	8 :	LO/REF
	0 1	1 0 1	0 0 0 :	9 :	Reference Synth
Control Cards	0 0	1 1 0	0 0 1 :	0 :	DDS
	- -	- - -	- - - :	1 :	μ P (no code)
	0 0	0 0 0	0 0 0 :	2 :	Control
	0 0	1 0 1	x x x :	3 :	Option Driver

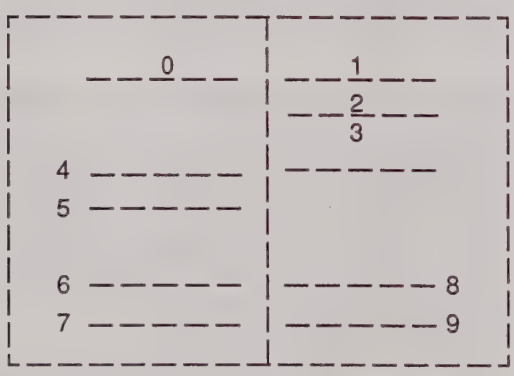
The two most significant bits (MSBs) indicate the card's functional history. When the bits are "0 0", the card currently installed in the slot is the one originally located there. A two bit code allows identification for up to four functionally different cards (the original card and up to three replacement cards) being used at any given position. These "function" bits may be used to indicate the options installed in the system.

The next three significant bits indicate the required card slot position of the card. Card slot locations are shown in Table 7-2. The card slot bits verify operation of the RF data and address busses. If a card is placed in an incorrect location, it will generate an RF data/address bus error. Missing cards are also detected when a card slot ID code is read and the position code is an illegal value.

The three least significant bits (LSBs) indicate the revision level of the card. The revision level is updated only for a hardware revision that requires a software modification.

The address decoding of the ID code latch for all cards is $00. Because the RF cards and the control driver cards are on separate data/address busses, card ID codes only need to be unique for the separate busses. Table 7-1 shows the ID codes currently defined.

TABLE 7-2
CARD LOCATION NUMBERING SCHEME:



7.3 MICROPROCESSOR BOARD

The Microprocessor (μ P) Board (see Figures 9-1 and 9-2) may be divided into communication and control sections. The control section (Figure 9-1) handles the internal interfacing tasks consisting of RF control data output and RF feedback data input. This section is also the math processor. Essentially, the calculation of the RF latch data are the only math operations performed. The communication section (Figure 9-2) handles the external interfacing tasks that include GPIB I/O, keyboard input, and display output. The communication section is a language processor, converting external input into a form usable by the control section, and converting data provided by the control section to a displayable form with meaning for the user. Because the communication μP handles most of the system I/O, and therefore initiates most of the internal communication, it is the master controller of the system. Each section is governed by a separate μ P. The two microprocessors communicate with each other through a shared dual port RAM (shown on Figure 9-1).

The communication μP handles the GPIB and keyboard inputs in solitude until execution of a setting or toggle function is complete. Then the input data is converted to the language of the control μ P, and fed to it via the dual port RAM. An interrupt will be issued to "wake" the control μ P, if necessary, so that it can perform the necessary calculations to update the data in the RF latches. If return information is necessary (feedback errors, deviation reading, etc.), the control μP will perform any necessary mathematical calculations on the data and return it to the dual port RAM. It will then issue an interrupt to the communication μP to get its attention, so that it can reformat the data for the display. This arrangement minimizes the amount of communication needed between the microprocessors. The dual port RAM provides a method of sharing common information with a minimum of software overhead.

Both sections (control and communication) contain their own μ P, EPROM, local RAM, parallel I/O interface, and reset, decode, and interrupt circuitry. A single dual port RAM is shared by both sections. The control I/O section includes the parallel RF control data interface and the feedback data interface. The communication I/O section includes the GPIB interface, keyboard interface, and LCD data interface.

7.3.2 CONTROL SECTION CIRCUITRY

The Control Section of the Microprocessor Board is shown on Figure 9-1. IC101 is the control microprocessor. Lines AD0-AD7 (pins 37-30) are the data bus. Lines A8 - A15 (pins 29 - 22) are address lines. The read/ write (R/W) output line is at pin 38. The interrupt request (IRQ) input at pin 5 may be from the communication microprocessor (INTCOM, low) from pin 44 of dual port RAM IC112 to pin 13 of NAND gate IC109 or a system interrupt (INTCTA, low) from pin 41/ 42 of Peripheral Interface Adaptor (PIA) IC105 to pin 1 of NAND gate IC109. (The INTCTB, low, interrupt line at pin 2 of NAND gate IC109 is not used at this time. It is reserved for future expansion.)

The reset (RST, low) signal at pin 6 is generated from + 5 V regulator IC137 on power up. This circuit resets

the control μ P and the communication μ P (Figure 9-2). The reset provided for the RF control boards is generated under software control.

Lines P17-P10 and P24-P22 (pins 20-10) are used for factory test purposes only.

The crystal (X101) input at pins 2 and 3 is divided by 4 internally to produce the control microprocessor clock.

Address Latch IC102 demultiplexes the input from data lines D0R-D7R (pins 2-9) to output address lines A0-A7 (pins 19-12). IC102 is enabled at pin 11 by the control microprocessor.

The Microprocessor Board control section memory is in EPROM IC103 (32K x 8), non-volatile RAM IC104 (8Kx8), and Dual Port RAM IC112. The NAND gates in IC111 and Inverters in IC107 that connect to pins 1 and 26 of RAM IC104 are for future bank switching decode logic. They are not used in the 2405/2410A.

Peripheral Interface Adaptor (PIA) IC105 receives system interrupts at pins 3-10 from pins 26A-29C of P102. These are output at pins 37-29 onto data lines D0R-D7R to the control microprocessor to identify the particular interrupt generated. The interrupts at P102 also are fed to NOR gate IC113. Any interrupt will be felt at pin 44 of PIA IC105 and generate the INTCTA, low, interrupt signal at pin 41/42 that is sent to the control microprocessor telling it to interrogate the PIA to determine which system input generated the interrupt.

Contact AA1 of Dipswitch SW101 is normally OFF, set for a 27C256 or equivalent to be used for the control microprocessor PROM. Contact AA2 of Dipswitch SW101 is set OFF for normal operation. When set ON, software skips modulation frequency and feedback error scanning and runs test routines in background. The microprocessor data/address bus to the control card may be tested in this configuration. Contact AA3 of Switch SW101 is reserved for future expansion and not used in the 2405/2410A.

PIA IC106 is an I/O device. Pins 3-10 connect to the data bus (D0-D7) at pins 17A-20C of P102. The data bus is bidirectional. Pins 11 and 13-15 of PIA IC106 provide output to the address bus (A0-A3) at pins 21A-22C of P102. Pins 16-19 are Board Selects 0, 1, and 2, and the R/W signal output to pins 23A-24C of P102. Pins 20, 21, 44, and 43 are for future expansion and are not used in the 2405/2410A. Interrupt INTCTB at pin 41/42 is not used in the 2405/2410A.

The port decode logic for PIA chips IC105 and IC106 is the NAND gate (from pins 9-11 to pin 8) in IC110 and the Inverters in IC108.

Dual port RAM IC112 is common to both the control and communication sections of the Microprocessor Board. The microprocessors for each section communicate through IC112. The left side of IC112 communicates with the communication section of the Microprocessor Board. The right side of IC112 communicates with the control section of the Microprocessor Board. Interrupt INTCOM, low, from pin 44 is applied through pin 13 of NAND gate IC109 and inverter IC107 to pin 5 of control microprocessor IC101 to tell it that the communication microprocessor has an execution request. Interrupt INTCTL, low, from pin 4 is applied through pin 2 of NAND gate IC134 and Inverter IC135 to pin 5 of communication microprocessor IC121 (Figure 9-2) to tell it that the control microprocessor has an execution request.

7.3.3 COMMUNICATION SECTION CIRCUITRY

The Communication section of the microprocessor board is shown on Figure 9-2. IC121 is the communication microprocessor. Lines AD0-AD7 (pins 37-30) are the data bus. Lines A8-A15 (pins 29-22) are address lines. The read/ write (R/W) output line is at pin 38. The interrupt request (IRQ) input at pin 5 may be from the control microprocessor (INTCTL, low) from pin 4 of dual port RAM IC112 (Figure 9-1) or from the GPIB (INTGPI, low) from pin 19 of General Peripheral Interface Adaptor (GPIA) IC126, or the Keyboard (INTKEY, low) from pin 3 of NAND gate IC136.

The reset (RST, low) signal at pin 6 is generated from + 5 V regulator IC137 (Figure 9-1) on power up.

Lines P10-P17 communicate with the LCD Display.

The crystal (X102) input at pins 2 and 3 is counted down internally to produce the control microprocessor clock.

Address Latch IC123 demultiplexes the input from data lines D0R-D7R (pins 2-9) to output address lines A0-A7 (pins 19-12). IC123 is enabled at pin 11 by the communication microprocessor.

The Microprocessor Board communication section memory is in EPROM IC124 (32K x 8), RAM IC125 (8Kx8), and Dual Port RAM IC112. Signals at pins 2, 26, and 27 of EPROM IC124 are for future bank switching purposes. They are not used in the 2405/2410A.

Contact AA4 of Dipswitch SW101 is normally set ON to permit using a 27C512 or equivalent as the communication microprocessor PROM.

General Peripheral Interface Adaptor (GPIA) IC126 provides the interface to the GPIB. GPIB Drivers IC130, IC131, IC133, and IC133 transfer signals to and from

the GPIB at P111. The interrupt at pin 40 (INTGPI, low) of IC126 is applied to the communication microprocessor when the GPIB needs to be serviced.

Contact AA8 of Dipswitch SW101 is normally set ON and connects chassis ground to the GPIB cable shield.

Peripheral Interface adaptor (PIA) IC127 provides the interface between the Keyboard and the communications microprocessor. Pins 3-8 process ""row" information (see Section 7.13) from pins 9A-14A of P102. Pins 11 and 13-19 process ""column" information from pins 9C-16C of P102. Column information also is fed to NAND gate IC129. Any keypress will put a low into IC129, producing a high at its output (pin 8) which is applied to pin 20 of IC127. A rising edge at pin 20 will generate an interrupt at pin 41/42 which is transferred through the NAND gates in IC136 as the INTKEY (low) interrupt to the communications microprocessor (to pin 5 through IC134).

Programmable Logic Device (PLD) IC128 is a decoder. It decodes lines A15L-A12L into the chip selects and output enables on pins 19-16. Inputs ROMX0, ROMX1, and ROMX2 are for future ROM bank switching purposes and are not used in the 2405/2410A.

Contacts AA5, AA6, and AA7 of Dipswitch SW101 which provide inputs to pins 4-6 of IC122 are reserved for future expansion and are not used in the 2405/2410A. Signals ROMX0, ROMX1, and ROMX2 which provide inputs to pins 8-10 of IC122 are reserved for future expansion and are not used in the 2405/2410A.

Pins 16-19 of IC122 are output voltages that are used to set the contrast on the LCD. More than one may be active at a time, placing one or more of the four resistors (R159, R157, R168, or R158) in series with R156. The magnitude of the voltage output at pin 3A of P102 depends upon which resistors are chosen varying LCD contrast accordingly.

Pins 7, 20, 21, 44, and 43 of IC122 are not used in the 2405/2410A. The interrupts at pins 41 and 42 of IC122 are not used in the 2405/2410A.

7.3.4 COMMUNICATION BETWEEN CONTROL AND COMMUNICATION MICROPROCESSORS

Dual port RAM IC112 (Figure 9-1) is common to both the control and communication sections of the Microprocessor Board. The microprocessors for each section communicate through IC112. The control microprocessor interrupts the communication microprocessor by writing a memory location in the Dual Port RAM, and the communication microprocessor clear it by reading from the same location. The communication microprocessor interrupts the control microprocessor by writing to another memory location also in the Dual Port RAM, and the control microprocessor clears it by reading from the location written to. The data written to these locations is in the form of a flag indicating the type of the data being transferred. The interrupted microprocessor always returns this value to a 0, after accepting the interrupt. The communication microprocessor always initiates the data exchange by first setting up the data to transfer in the Dual Port RAM, then writing a code to location to the RAM that interrupts the control microprocessor and indicates the type of data to be transferred. The control microprocessor then clears this location, accepts the data transferred (usually by executing a setting), then returns an error code to the communication microprocessor by writing it to the Dual Port RAM. The communication microprocessor will then determine what error has occurred (if any) and take the appropriate display and/or GPIB action. The arbitration registers in the dual port RAM prevent the simultaneous setting and clearing of a microprocessor communication interrupt.

7.4 CONTROL BOARD

Refer to the two schematics associated with the Control Board (Figures 9-3 and 9-4) and Block Diagram Figure 7-8 (0013-10-0041) for the following discussion. The circuitry shown on Figure 9-3 will be described before the circuitry on Figure 9-4 is described, with the following exceptions. The temperature sensing circuitry of IC247 (Figure 9-3) will be described before the circuitry on Figure 9-4 is described, with the following exceptions. The temperature sensing circuitry of IC247 (Figure 9-3) will be described with the analog signals feeding into Multiplexer IC217 of Figure 9-4. The 1 MHz reference input at pin 6B of P200 (Figure 9-3) provides the clock for the clock control logic (IC222 and associate circuitry) on Figure 9-4.

7.4.1 OVERVIEW

The control board:

1) Generates the 400 Hz and 1 kHz modulation rate reference sources
2) Generates the FM deviation, AM depth, and levelanalog drive voltages for the RF modules
3) Transfers data between the Microprocessor Board and RF modules (keeping the data and address busses static on the RF side)
4) Multiplexes a variety of analog inputs so that a single A/D convertor can read all the analog feedback lines
5) Performs a peak detection of the analog input selected
6) Generates the select lines for the attenuator
7) Provides RF circuit breaker protection on the RF

output

8) Provides self-check capabilities for the analog drive outputs, the mod rate frequency, and the RF module data and address busses (including the ability to identify the RF cards currently installed in the system)

7.4.2 INTERNAL MODULATION CIRCUITRY

The 4 kHz modulation reference from the Reference Synthesizer Board at pin 7C of P200 (see Figure 9-3, the Control Board Schematic, sheet 1 of 2) is counted down by 2 and counted down by 5 inside Counter chip IC230 to generate a 2 kHz output at pin 3 and an 800 Hz output at pin 7, respectively. Both output signals are applied to Quad NAND GATE IC233. The circuitry in IC233 is enabled by a 400 Hz or a 1 kHz enable signal from Latch IC249. The appropriate switch in Nand Gate chip IC233 is enabled (the 400 Hz enable at pin 5 or the 1 kHz enable at pin 2) to pass either an 800 Hz or a 2 kHz signal through IC223 (output at pin 8) back into Counter IC230 (at pin 15). That input is counted down by 2 again and output as a 400 Hz or 1 kHz signal at pin 13.

The TTLMOD output shown between pin 13 of Counter IC230 and pin 10 of Nand Gate Chip IC233 goes to pin 9 of ID Buffer IC208 (Figure 9-4) and provides the microprocessor input used to verify the 400 Hz signal.

The 400 Hz modulating signal is selected from pin 13 of IC233 through to pin 11 by the 400 Hz enable at pin 12. The 1 kHz modulating signal is selected from pin 10 of IC233 through to pin 8 by the 1 kHz enable at pin 9. Amplifier IC234 and its associated circuitry form a two stage low pass filter with amplification for the 400 Hz signal. The $5V_{p-p}$ TTL signal at pin 11 of IC233 is amplified to a $20V_{p-p}$ signal at pint 7 of IC234. R267 provides the 400 Hz signal output level adjustment. Amplifier IC235 and its associated circuitry form a two stage low pass filter with amplification for the 1 kHz signal. The $5V_{p-p}$ TTL signal at pin 8 of IC233 is amplified to a $20V_{p-p}$ signal at pin 7 of IC235. R281 provides the 1 kHz signal output level adjustment. The selected modulating signal (400 Hz or 1 kHz) is applied to pin 2 of unity gain amplifier IC236, buffered, and output at pin 6 to pin 3 of Quad Switch IC237 and pin 3 of Quad Switch IC238.

Quad Switches IC237 and IC238 (Figure 9-3) are controlled by software through Latch IC249. An internal AM signal at pin 3 of IC238 will be passed through to pin 2 if the control signal at pin 1 is low (to put the switch in the closed position). An external AM signal at pin 6 of IC238 (see section 7.4.3) requires that switch to be closed (low at pin 8) before the signal can pass through to pin 7. The voltage at pin 8 opens or closes the switch. The control voltages at pins 1 and 8 come from pins 14 and 13, respectively, of Latch IC249. The selected AM signal (internal or external modulation) is applied to pin 8 of AM DAC IC244 (see section 7.4.5 for a discussion of the three DACs shown on Figure 9-3). When no AM signal should be present (AM off), a low at pin 9 (AM enable) of IC238 closes the switch from pin 10 to pin 11 and any incidental AM is shorted to ground through the switch.

FM signals are routed from pin 3 to pin 2 (Internal Modulation) or from pin 6 to pin 7 (External Modulation) of Quad Analog Switch IC237. Control voltages applied to pins 1 and 8 of these switches come from pins 17 and 16, respectively, of Latch IC249. The selected FM signal (internal or external modulation) is applied to pin 8 of FM DAC IC242 (see section 7.4.5 for a discussion of the three DACs shown on Figure 9-3). When no FM should be present (FM off) pin 9, the FM enable, of IC237 closes the switch from pin 10 to pin 11 and any incidental FM present is shorted to ground through the switch.

Pin 16 of IC238 is associated with the FM deviation range (see Section 7.4.4).

7.4.3 EXTERNAL MODULATION

For the Model 2405/2410A, the external modulation input to the Control Board is at P203. This input comes from the FP MOD IN connector except when the optional deviation meter is installed. When the Dev meter is installed ext modulation is routed through the Dev meter and then to the control card P200 pin 2B. Section 7.15 details its routing.

The external modulation input is a 1 V signal that is amplified by Amplifier IC239 and its associated circuitry into a 20 V [in'p-p'] output at pin 6 of IC239. This output is applied to the external modulation inputs to Quad Switches IC237 (pin 6) and IC238 (pin 6). The action of these switches are described in section 7.4.2. The external modulation signal may be enabled through the appropriate switch into the FM (IC242) or AM DAC (IC244).

7.4.4 CONTROL BOARD DAC CIRCUITRY

The three DACs (FM DAC, IC242; AM DAC, IC244; and LEVEL DAC, IC245) shown on Figure 9-3 are enabled by signals from Latch IC248 (FMEN, AMEN, LEVEN, respectively; all active low) to pin 1 of the appropriate DAC. Inputs to each DAC are at pin 8. Each is a 12-bit DAC served by an 8-bit data bus (RFD0-RFD7), therefore the 12-bit control word to the DAC must be written in two stages: the first 8 bits, then the last 4 bits. The sequence to write to any DAC is as follows. First, the DAC is enabled by a low at its pin 1. Then the upper and lower

bytes are written to the DAC, with the MSB (Most Significant Bit) written first, followed by the LSB (Least Significant Bit).

After the LSB has been written, the entire 12 bits is latched out to the DAC. The bit configuration for the DACs is shown in Table 7-3.

Address bus signals RFA3 and RFA4 from Data Latch IC205 (on Figure 9-4) determine the control word write sequence to the DACs. Each DAC multiplies its input at pin 8 by the control word from the data bus. The output from its associated Dual Buffer/Amplifier (pin 1 of IC243, IC253, or IC246) is fed to a downstream amplifier (the other half of the Buffer/Amplifier) and also fed back to pin 9 of the DAC to provide feedback. A sample of the output from each DAC sent to Multiplexer IC217 shown on Figure 9-4 (see section 7.4.6). The three DACs serve different functions but are identical in performance. The FM DAC (IC242) will be described and compared with the remaining two DACs.

FM DAC IC242, one half of dual op amp IC243, and their associated capacitors (C245, C246, and C250) comprise the FM DAC circuitry shown in Figure 9-3. The FM input at pin 8 of FM DAC IC242 is multiplied by the control word from data bus RFD0-RFD7, when this DAC has been selected by a low at pin 1, the FM DAC enable. The output at pin 1 of IC243 provides DAC feedback to pin 9 and is applied to pin 5 of IC243. The amplified signal goes through pin 4B of P200 to the RF Synthesizer Board (see section 7.7). A sample of the output is sent to Multiplexer IC217 shown on Figure 9-4 (see section 7.4.6).

The FM DAC circuitry contains an FM range selector not found in the other DAC circuitry. "A" and "B" taps on either side of R297 and R213 (located between pin 1 and pin 5 of IC243) connect to pins 15 and 14, respectively, of Switch IC238. The control signal FMRG at pin 16 determines whether the switch is closed (and R297 and R213 are shorted out of the circuit) or whether the switch is open (and R297 and R213 are in the circuit). Signal FMRG comes from pin 17 of Latch IC248.

The deviation ranges are:
Range 1: 0 - 99.9 kHz; R297 and R213 in the circuit
Range 2: 99.9 kHz - 1 MHz; R297 and R213 not in the circuit

TABLE 7-3. CONTROL DAC BIT CONFIGURATION

R/W	DATA NAME	b7	b6	b5	b4	b3	b2	b1	b0
W	DAC data xfer contrl	x	x	x	/XFR	/WRT	x	x	x
W	Selected DAC Hi Data	D11	D10	D9	D8	D7	D6	D5	D4
W	Selected DAC Lo Data	D3	D2	D1	D0	x	x	x	x
W	DAC select latch	/LEV	/AM /	FM	x	x	x	x	x

Table 7-3 Definitions:

/XFR =High byte/Low byte select and DAC transfer enable lines
1 = Enable /WRT to MSB latch, disable /WRT to DAC transfer latch
0 = Disable /WRT to MSB latch, enable /WRT to DAC transfer latch
(LSB latch always enabled)

/WRT Write MSB latch, LSB latch, and DAC transfer latch
0 = Transfer data from input to latch output
1 = Latch data (disable output from following input)

/LEV Chip select Level DAC (0 = enable, 1 = disable)
/AM Chip select AM DAC (0 = enable, 1 = disable)
/FM Chip select FM DAC (0 = enable, 1 = disable)

Dxx (12) Selected data bits. D11 is MSB and D0 is LSB.

When all modulation is turned off, the Modulation DACs are programmed for minimum outputs.

The comparable DAC circuitry output from the AM DAC at pin 1 of IC253 provides feedback for the DAC and is sent to pin 3C of P200 and then to the AM/Divider Board (see section 7.10). A sample of the output is sent to Multiplexer IC217 shown on Figure 9-4 (see section 7.4.6). The output also goes through the other half of the dual amplifier (pins 6 to 7) and provides the input to LEVEL DAC IC245. The LEVEL DAC output at pin 3A of P200 goes to the Output Board (see section 7.11) where it is used with AM in the leveler range from 10 Hz and below. A sample of this output also is sent to Multiplexer IC217 shown on Figure 9-4 (see section 7.4.6).

7.4.5 DATA TRANSFER

Refer primarily to Figure 9-4 for the following discussion. Data latches IC203, IC205, and IC206 transfer data on buss lines D0-D7 from the microprocessor to the RF modules. IC203 provides device Select Lines SEL0 through SEL5, all active low (pins 23A,B,C and 24A,B,C of P200) to the RF modules. IC205 provides Address Lines RFA0 through RFA4 (pins 29C,B,A and 28C,B of P200). IC206 provides Data Lines RFD0 through RFD7 (pins 27B, A and 26C,B,A and 25C,B,A of P200). Buffer IC207 reads the RF data bus back to the microprocessor from the RF modules. Buffer IC208 is the ID buffer, transferring the board ID information back to the microprocessor when selected. The ID buffer also transfers the 400 Hz test signal TTLMOD described in section 7.4.2 and the reverse power protection signal TRIP described in section 7.4.9 back to the microprocessor).

The data latches and both buffers receive device selects from decoders IC204 and IC211, which form a 1:16 decoder, decoding lines $I0_0$, A3, A2, A1, and A0. The data, address, and card select busses on the RF module side are static in the sense that they change only when new data is written to the RF modules.

7.4.6 ANALOG FEEDBACK SIGNAL MULTIPLEXING

The FM, AM, and LEVEL DAC output signals and the TEMPSENS signal from temperature sensing device IC247 (shown on Figure 9-3) are multiplexed by Multiplexer IC217 shown on Figure 9-4. The test and calibration signal TPX (pin 1C of P200) from the RF Synthesizer Board (see section 7.6) and the Deviation Meter Board (see section 7.15) and + 10 V and ground signals are also multiplexed by IC217. The selected output from pin 12 of the multiplexor is applied to pin 5 of Comparator IC220. IC220 is part of the peak detection circuitry described in section 7.4.7.

Latch IC224 provides select and enable logic (pins 16-19) for the multiplexer (pins 3, 4, 1, and 16). Data lines D0-D7 from the microprocessor control Latch IC224 outputs. The Latch chip select (a low at CE7) comes from Decoder IC204.

7.4.7 PEAK DETECTION CIRCUITRY

The peak detection circuitry includes D/A Converter IC218, Comparator IC 220, Dual Operational Amplifier IC219, Gates IC221, IC222, and IC223, Up/Down Counters IC225, IC226, and IC227, and Buffers IC228 and IC229. The analog inputs to IC217 are multiplexed into the peak detection circuitry and measured. Peak detection is performed digitally, and is implemented by driving a 12-bit DAC with a 12-bit binary counter, enabling the counter clock as long as the output of the DAC is less than the analog input to which it is compared. Both positive and negative peaks can be detected by inverting the polarity of the enable signal and the direction of the count. The counter is clocked by a 1 MHz reference or the microprocessor. This setup allows the microprocessor to test the peak detector circuit.

The multiplexed analog input from Multiplexer IC217 (pin 12) is applied to pin 3 of Comparator IC220 and compared to the A/D Converter output at pin 2. The difference is applied to pin 1 of Exclusive OR Gate IC221 and is routed through the clock control logic of NAND gates in IC223 and IC222. The 1 MHz signal at pin 4 of IC222 is the clock for the A/D Converter. It comes from the REF/LO Board (see section 7.8) and enters the Control Board at pin 6B of P200 (shown on Figure 9-3).

A high or a low from pin 13 of Latch IC224 will be loaded into Up/Down Counters IC225 through IC227 to set their 12 output bits (pins 3, 2, 6, and 7 on each chip) to the D/A Converter (input at pins 4-15) to produce a + 10 V or a -10 V level at pin 2 of Comparator IC220. For positive peaks, any time the DAC output is lower than the analog input at pin 3 of Comparator IC220, it will generate a low at pin 7. The low will be passed from pin 1 of Exclusive OR gate IC221 through the clock control logic and increment the Up/Down Counter string until the DAC output is identical to the analog input to the Comparator. When this occurs, pin 7 of IC220 will go high, pin 1 of IC221 will go high, and this will turn off the clock. Note that the A/D Converter will require several cycles to match a sinusoidal input analog signal. The clock will decrement the counter string during those times the input signal is higher than the DAC output. When the peak signal for a positive peak has been determined, the output from pin 7 of Comparator IC220 will remain high throughout the input signal swing. The output from pin 3 of IC221 will remain low throughout the cycle. No further counter changes will occur. For negative

peaks, a DAC output higher than the analog input at pin 3 of Comparator IC220, will result in the clock incriminating the counter string. When the peak signal for a negative peak has been determined, the output from pin 7 of Comparator IC220 will remain low throughout the input signal swing. The output from pin 3 of IC221 will remain high throughout the cycle. No further counter changes will occur. The PEAK signal at pin 3 of IC21 is applied to pin 9 of Buffer IC228 and read back to the microprocessor to indicate the peak value has been obtained. That 12-bit value is on lines 2-9 of Buffer IC229 and lines 2-5 of Buffer IC228 and is read back to the miroprocessor on data lines D0-D7 when the buffers are selected (chip selects are lows at CE8 and CE9).

One half of IC219 (at pin 2 of the D/A Converter) serves as a current compensation device, adding the equivalent current of one half a Least Significant Bit to the D/A output current.

The analog multiplexer inputs include a ground and +10 volt reference. These selections allow self calibration of the A/D Converter without adjustments.

7.4.8 ATTENUATOR CONTROL

IC201 is the attenuator Driver. IC202 is the Latch for the attenuator driver. The Latch select at pin 11 of IC202 comes from pin 9 o Decoder IC204. The RESET low at pin 12 of Exclusive OR gate IC221 is a microprocessor signal to enable the Attenuator Latch (at pin 1) after power up has been accomplished.

7.4.9 REVERSE POWER PROTECTION

Reverse power protection is provided by comparator IC216 and transistors Q203 and Q201 and their associated circuitry. Transistor Q202 and its associated circuitry provide the reverse power protection reset path. The actuating signal comes from the reverse power detector in the Programmable Attenuator and enters the Control Board at pin 22C of P200. This signal is applied through R208 to pin 2 of comparator IC216. It is compared to the reference voltage at pin 3. When the voltage at pin 2 is greater than the reference voltage at pin 3 it trips the reverse power protection circuit. The output at pin 1 of IC216 goes low (approximately -13 V) and causes transistor Q203 to turn off. The collector (pin 3) of Q203 goes high (+5 V), applying a high (+5 V) to the TRIP output that goes to pin 8 of ID Buffer IC208 (and is read as an Interrupt by the microprocessor). Transistor Q201 normally is turned off when RF power is on. When the collector (pin 3) of Q203 goes high, transistor Q201 is turned on, producing a low at its collector (pin 3) which is applied to pin 8 of Attenuator Driver IC201. The signal at pin 8 drives the RFEN output at pin 11, which controls the drive relay at the Attenuator. A low at pin 8 of IC201 turns off the drive relay, turning the RF off. Until it has been reset, the reverse power protection circuit will continue to output the TRI interrupt, and hold RF off.

A RFON low at pin 8 of Exclusive OR gate IC221 serves to reset the reverse power protection circuit. The RFON high comes from the microprocessor when the front panel RF ON/OFF switch is toggled. The high is applied to pin 1 (Base) of transistor Q202, turning it on. When Q202 turns on, a negative going AC coupled pulse is applied through diode CR201 to pin 2 of Comparator IC216. Because pin 2 is lower than the reference signal at pin 3, the output at pin 1 becomes high again (as it was before the TRIP occurred). The high at pin 1 is applied to Q203, turning it on. When Q203 conducts, TRIP goes low and the RF power can be turned on again. The reverse power protection circuit is reset when Q203 conducts and its output from pin 3 goes low.

The next RFON low will turn on the RF again (assuming the condition causing the TRIP interrupt has corrected itself or been corrected). The RFON low comes from the microprocessor when the front panel RF ON/OFF switch is toggled. The low is applied through R202 to the base of Q201 (pin 1), turning it off. When Q201 turns off, pin 3 goes high. The high is applied to pin 8 of Attenuator Driver IC201. The RFEN output at pin 11 turns on the attenuator drive relay and RF is applied to the output.

7.5. DIRECT DIGITAL SYNTHESIZER BOARD

7.5.1 OVERVIEW

Refer to block diagram Fig 7-3 (0013-10-0036). The Direct Digital Synthesizer (DDS) circuitry shown in Figure 9-5 controls fine frequency resolution of the Reference Synthesizer Board. The DDS output frequency is 1.0 MHz to 1.9999999 MHz in .1 Hz increments to maintain the .1 Hz instrument resolution.

The output from the DDS circuit is generated from a look up sine table stored in PROMs accessed by a phase accumulator network. The output from the phase accumulator network provides the PROM address from which a 12-bit binary voltage representation is taken. The PROM address is incremental some number (the phase increment input from software) at each clock pulse to generate (synthesize) the required output frequency. The phase accumulator section processes the phase increment input (frequency control number) from software to increment a series of BCD Adders the required number. The 12-bit binary output from the sine table is converted into an equivalent current by a DAC, amplified, and filtered. The filtered signal is sent to the Reference Synthesizer.

7.5.2 SINE TABLE

The output from the DDS circuit is generated from the look up sine table in PROMs IC125 and IC126 as they are accessed by the Phase Accumulator Network. The PROMs contain 2000 addresses with 12-bit binary numbers which represent the voltage levels at 0.09 degrees of phase angle along 1/2 a sine wave. Each address in sequence from 0000 to 1999 contains the voltage representation associated with that point on the sine curve.

In order to generate the other 1/2 of the sine wave, the outputs from the PROMs are inverted by exclusive OR gates ICs 142, 143, and 144. This inverts the waveform map and produces a ""mirror image" of the first half of the sine wave. The MSD of the phase accumulator controls when the inversion takes place.

7.5.3 PHASE ACCUMULATOR NETWORK

The phase accumulator network includes octal D flip flops IC's 104-109, 111,112 and 121-124, BCD adders, IC's 117-124 and dual D flip flop IC 139. The phase increment data ""k" is written to IC's 104-109 in 4 consecutive 8 bit wide words. Decoder IC 102 selects which IC the phase increment data is written to. This 32 bit wide word is then transferred simultaneously to the inputs of the BCD adders. This buffers the phase accumulator from the digital interface which prevents any discontinues during frequency changes.

The BCD adders (IC's 117-124) are configured such that their sum value ""n" at D1-D8 of IC's 121-124 is incriminated by "k" on every clock pulse from the 10 MHz reference (pin 27A of P101). The output from the phase accumulator provides the address input (lines A0-A12 on IC 125 and IC 126) to the SINE table PROMS from which the 12 bit binary voltage representation is taken. IC 125 holds the most significant data byte. IC 126 holds the least significant data byte. The 10 MHz reference clocks the flip flops (IC 121-124) to latch the address which is the new accumulator value. For example, if k = 1, then at each clock pulse the look-up address ""n" is incriminated by 1. The phase accumulator network is reset to n = 0 any time frequency is changed; therefore the first frequency control number clocked through the D flip flops to the adder series and into the sine table PROM is n = 0. At the next clock pulse the address is incriminated k = 1 to address n = 1. At the next clock pulse the address n = 1 is incriminated by k = 1 and becomes n = 2. Flip-flops IC121 - IC124 provide feedback as shown to the series of adders. The address increment sequence with k = 1 is shown below:

for k = 1

0000 first address $n_1 = 0$ (reset)
0001 $n_2 = n_1+k = 0+1 = 1$
0002 $n_3 = n_2+k = 1 + 1 = 2$
0003 $n_4 = n_3+k = 2 + 1 = 3$
.
.
.
0999
1000
1001
.
.
.
1998
1999
0000 rolls over to 0000 again

When k = 1, each address of the look-up table PROM is accessed at a rate of 1 address per clock cycle (.1 msec). It requires 200 µsec to get 1/2 cycle and 400 µsec for 1 entire cycle out at this address increment (frequency control) number. The output frequency at k = 1 is therefore

$$fo_0 = \frac{1}{400\ \mu sec} = 2.5\ kHz$$

Consider the case when k = 5. The phase accumulator is reset to n = 0 but each successive increment (k = 5) increases the phase angle of the output by .45 [deg] (.09 [deg] x 5) skipping to every fifth address (rather than every address as when k = 1). The address sequence will be:

for k = 5
0000 first address $n_1 = 0$ (reset)
0005 $n_2 = n_1+k = 0 + 5 = 5$
0010 $n_3 = n_2 +k = 5 + 5 = 10$
0015 $n_4 = n_3+k = 10 + 5 = 15$
.
.
.
0995
1000
1005
.
.
.
1990
1995
0000 rolls over to 0000.

When k = 5 the complete look-up table is accessed five times as rapidly as when k = 1 because every fifth address is accessed at each clock pulse. It requires 400 clock pulses (.1μsec/pulse) to generate 1/2 cycle out 800 clock pulses for 1 entire cycle). Therefore the output frequency at k = 5 is

$$f_o = \frac{1}{80\ \mu sec} = 12.5\ kHz$$

The general equation for output frequency (f_o) as a function of phase offset (k) is:

$$f_o = f_{clk} \times \frac{k}{n_{full\ scale}/2}$$

where f_{clk} = the frequency of the clock = $1x10^7$] Hz and $n_{full\ scale}$ is 2000 or the maximum number of PROM addresses available.

Note that this equation expresses output frequency as a function of the rate at which one complete cycle is synthesized from the look-up table PROM. That rate is a function of the address increment steps k, used to step through the table.

The 10 MHz reference (pin 27A of P101) for the DDS circuit provides clock pulses at .1 μ sec intervals.

BCD adder IC 120 processes the least significant digit of the frequency control number. IC 116 processes the next least significant digit. IC's 120, 116, 119, 115, and 118 do not address the PROM therefore these five adders allow k to be a fractional value as low as .00001 permitting an output frequency resolution of .025 Hz. For example if k = .00001,

$$Fo_0 = (1x107]\ Hz \times .00001/2000)/2 = .025\ Hz.$$

When the .00001 digit controlled by IC120 is full, the carry (pin 6 of IC120) steps IC116 up one unit (.0001). When the .0001 digit controlled by IC116 is full, the carry (pin 6 of IC116) is fed to IC119 (pin 5) to step the .001 place up one unit. This process continues through all of the BCD adders, IC's 120, 116, 119, 115, 118, 114, 117, and 113. IC 140 and its associated AND and EXCLUSIVE OR gates, IC's 138 and 141 serve to extend the adder by 2 bits. The MSB of the phase accumulator is not decoded by the PROMS but instead it is used to invert the waveform map from the PROMS which generates the 2nd half of the SINE waveform. In summary, at each clock pulse the phase accumulator network provides an address that is latched through octal flip-flops (IC121-IC124) into the sine table PROMs. The address is incriminated some value k (the phase increment input; the frequency control number) at each clock pulse. This number k is basically the number of degrees along the sine curve that the address n is incriminated at each clock pulse.

7.5.4 DAC IC321

The output from the PROMs at each clock pulse is a 12 bit binary number representative of the sine wave voltage at the associated sine wave phase angle. This number is latched by flip-flops IC127 and IC128 into 12-bit DAC IC132. The 10 MHz ref clocks the 12-bit binary word through IC127 and IC128 into the DAC (IC132).

DAC IC132 converts the input binary word into the equivalent output current at pin 20. The output is fed to pin 5 of amplifier IC133. The output at pin 10 of IC133 is applied to a low pass filter network. This filter eliminates the frequency component introduced as a result of the step nature of the sine table waveform. The cutoff for the low pass filter is 3.3 MHz. The DDS output is fed via J100 to the Reference Synthesizer Bd.

7.5.5 ID BUFFER

ID buffer IC103 provides the ID code (see Section 7.2.2) for the DDS Board.

7.6 REFERENCE SYNTHESIZER

7.6.1 OVERVIEW

(Refer to figs 9-8 and 7-4 (0013-10-0037) for schematic and block diagrams) The primary function of the Reference Synthesizer is to provide a stable frequency reference for the main synthesizer loop on the RF Synthesizer. This reference must also have very fine frequency resolution in order to maintain .1 Hz resolution at the instrument output. The Reference Synthesizer also provides a 4 kHz reference signal that is used to generate the 1K and 400 Hz modulation signals on the Control board.

The Reference Synthesizer PLL is a single loop design with a double balanced mixer in the feedback path used to offset the output frequency by 1 MHz.

7.6.2 LOOP OPERATION

The output signal from the DDS board is fed through J1501 and transistor amplifier stage Q1509 to a DIVIDE BY N circuit made up of IC1507, 1508 and 1509. The value of N is a function of the FP frequency setting and can range from 274 to 549. This results in a frequency of Fdds/N being fed to one input of the phase detector,

IC1518. The other input to the phase detector originates from the 32 MHz oscillator.

The 32 MHz VCO is made up of Q1503 and its associated components (shown within dashed lines on the schematic). Resistors R1537, 1538, 1539 and 1574 set the DC operating point for Q1503. C1553 and C1554 form an AC voltage divider to provide feedback which maintains oscillation. The main frequency determining components are, C1548, C1549, C1552, L1501, and variactor diode CR1504. The DC voltage from the loop filter at L1503 fine tunes the VCO by changing the reverse bias applied to CR1504 which varies its capacitance. The frequency range of the VCO is from 32.058288 MHz to 32.233577 MHz (for FP output frequencies of 549 to 275.9999999 MHz).

The output of the VCO is fed to a divide by 32 prescaler (IC1516) which results in a frequency range of 1.0018215 to 1.0072993 MHz This signal is routed to two inverters (IC1517). The output of one of the inverters is fed to the output connector, J1502 where it is then connected to the input of the RF Synthesizer. The other inverter output is fed to a transistor emitter follower stage made up of Q1504 and its associated components. The emitter follower drives the RF input of mixer MX1501 through a 50 ohm attenuator pad.

The mixer LO input is driven by an amplified version of the instrument 1 MHz. reference signal. This causes the output of the mixer at pins 3 and 4 to be offset in frequency by 1 MHz. resulting in an output frequency range of 1.8215 kHz to 7.2993 kHz There are also higher frequency (sum) components at the mixer output but these are attenuated by a 100 kHz low pass filter made up of C1535, C1536, and L1504. The mixer output is converted to 5 V pulses by IC1519 which is a comparator configured as a zero crossing detector. This pulse train is then fed to the other input of the phase detector IC1518.

The phase detector outputs at pins 5 and 6 of IC1518 are routed to the loop filter, IC1512 and its associated components. The loop filter integrates the pulses from the phase detector an generates a DC frequency correction voltage at its output. The other half of IC1512 inverts the polarity of the correction voltage and applies it to the VCO through R1534. The loop filter is design to be switched between wide and narrow bandwidth modes. Q1502 and 1508 are FET switches that when on, connect resistors R1571 and R1572 in parallel with R1518 and R1517 respectively. This results in a wide bandwidth so the loop may switch faster when the output frequency is changed or on power up. After the loop has settled on frequency the FET switches are turned off which results in a narrow loop bandwidth which helps attenuate noise generated in the loop.

The output of the loop filter, pin 1 IC1512 is also fed to an unlock detector (IC1513, CR1501, CR1502 and their associated circuitry). Pin 14 of IC1513 goes to +13VDC whenever the loop filter output signal is greater than ±10 VDC. CR1503 is a 5.1 V zener diode so the INT 5 (UNLOCK 3) signal at pin 26 P1501 will be approximately 5.1 V when the Reference Synth board is unlocked. This signal is routed to the microprocessor board for STATUS interrupt processing. The loop filter output is also routed to IC1513 pin 9. Pin 8 of IC1513 goes to -13 V whenever the loop correction voltage goes above 0V and stays there until the loop correction voltage goes down to -10 V This turns on transistor Q1507 which shunts one input to the phase detector to ground. The above process keeps the loop from latching up on the incorrect mixer product. For instance, if the nominal reference frequency is 1.8215 kHz, the image frequency for this IF frequency is only 1.8215 kHz x 2 = 3.643 kHz away. Whenever the input at pin 2 of the phase detector is shunted to and the loop filter output will automatically tune the VCO the proper direction to regain lock.

Transistor tuned amplifier stage, Q1501 and push pull amplifier, Q1505 and 1506 serve to amplify the 1 MHz. reference to a high enough power level to drive the mixer MX1501.

The VCO tuning voltage at pin 7 of IC1512 is connected to analog switch IC1514 and is switched to pin 24 P1501 (TPX) during diagnostics.

7.6.3 MODULATION REFERENCE DIVIDER

IC1521 and IC1522 divide the 1 MHz. reference by 250 and output a 4 kHz square wave at pin 22 P1501. This signal is used to generate the 1 kHz and 400 Hz modulation sources on the Control board.

7.6.4 DIGITAL INTERFACE

IC's 1501 - 1504 make up the digital interface. IC's 1503 and 1504 are write latches. Data from the RF data bus is written to these latches to control the divide by N, BW, and TPx functions. IC1502 is the ID code buffer used to verify that the proper hardware is installed. IC1501 is the address decoder used to select the proper atch/ buffer.

7.7 RF SYNTHESIZER BOARD and VCO BOARD

7.7.1 OVERVIEW RF SYNTH

(Refer to blk diagram) Fig. 7-2 (0013-10-0035)

The RF Synthesizer board (See fig 9-6 for schematic) generates a 275 - 550 MHz. CW or frequency modulated signal that is applied to the doubler board (section 7.9). The synthesizer uses a single phase locked loop (PLL)

which incorporates fractional division techniques. The VCO board is attached to the RF synthesizer and produces an RF signal with a frequency range of 275 to 550 MHz.

The digital interface that controls the synthesizer board consists of a data bus, address bus, and a board select line. The signal from the Reference Synth Bd serves as the reference for the RF Synth. An FM input from the Control Board modulates the signal when unit is in the FM mode. An analog test and calibration signal (TPX) is output to the Control Board. An interrupt (INT) signal is output to the Microprocessor Board.

7.7.2 DIGITAL CONTROL

The synthesizer board accepts an 8-bit data bus (pins 15-8 of P401; data lines RFD0-RFD7), 2-bits (pins 34 and 33 of P401; RFA0 and RFA1) of a 5-bit address bus, and a card-select signal (pin 27 of P401; SEL 3). When the RF synthesizer board is selected by a low at SEL 3, there are three options for the data bus:

1. ID buffer IC406 is selected and the ID is transferred to the data bus to be read by the microprocessor.

2. Data latch IC404 is selected and the content of the data bus is transferred to it.

3. Control latch IC405 is selected and the content of the data bus is transferred to it.

The data on the data latch is used for the loop compensation and coarse tuning DACs in dual DAC IC414 and also for programming the PLL chips (IC407 and IC408).

The data on the control latch is used for strobing the main and auxiliary PLL chips (IC408 and IC407, respectively), switching the VCO bands (the BANDSW signal at pin 3 of VCO IC500), selecting CW or FM modes (pins 6 and 9 of Switch IC413), selecting the loop compensation or coarse tuning DAC and enabling writing into the selected DAC (pins 6 and 16 of dual DAC chip IC414), and enabling the analog signal (TPX) to the control board (pins 1,8 of Switch IC419).

7.7.3 RF SYNTHESIZER PHASE LOCK LOOP

The Synthesizer Phase Lock Loop (PLL) consists of Main PLL Synthesizer chip IC408, the switchable loop filter network composed of switch IC413 and buffers/op amps IC411 and IC417 and their associated circuitry, dual D/A convertor IC414, VCO IC500, Divide-by-10 Counter IC416, Phase Detector IC501, and the Divider Network of Dual Modulus Counter IC410 and Adder IC409. The frequency dividers in Auxiliary PLL chip IC407 also are used in the PLL.

The output signal from the Reference synthesizer bd is routed to J502 of the RF synth bd. This signal is then fed to the main PLL chip IC408 where its frequency is divided by 20 and output on pin 18. AND gate IC423 is configured as a digital switch and is used to select either the synth input directly or the divided by 20 output (for FM operation) from IC408 as one input to the phase detector IC501, pin 1. The other input to the phase detector is taken from the divider network (described later).

The outputs from the phase detector at pins 5 and 6 of IC501 are applied to the loop filter, which is switched into one of two configurations by Switch IC413. During operation in the CW mode, R406 and R407 are each shorted and C433 is not connected. During operation in the FM mode, R406 is in series with R408, R407 is in series with R409, and C433 is in parallel with C434. A control signal from pin 16 of Control Latch IC405 sets the switch to the CW or FM setting.

The output from the switched loop filter also is applied through diodes CR401 and CR402 to pins 9 and 10 of IC418. This circuitry forms a window comparator to check the output for saturation, which would mean the loop is unlocked (UNLOCK1). If the signal is outside a ± 10.0 V window, an interrupt signal (INT 3) will be sent to the Microprocessor Board through pin 26 of P401. The signal from the loop filter network is applied to pin 4 of dual DAC (Digital to Analog Convertor) chip IC414. IC414 contains two DACs and their associated registers and circuitry. This chip performs two functions. It provides loop compensation to maintain constant loop bandwidth and also provides the coarse tuning signal. One of the two registers in IC414 holds the number by which the loop compensation DAC input is multiplied. The other register holds the number by which the coarse tuning DAC input (a constant + 15 V at pin 18) is multiplied. The DAC multipliers are on data bus lines D0-D7 from Data Latch IC404 and are applied to IC414 pins 14-7, respectively. The registers are controlled by signals at pins 6 and 16 (from Control Latch IC405). One control signal is a write enable, the other selects which buffer is written to. The coarse tuning voltage is output at pin 20, the loop compensation voltage at pin 2. The two voltages are summed and output at pin 1 of Output Amplifier IC417. The output goes through 100 kHz trap (R432, R444, L404, and C476) and has the FM signal (from pin 2 of Switch IC413) added to it. The FM signal enters the board at pin 5 of P401 (FM Return at pin 6), goes through Buffer/amp IC417, and through Switch IC413 (pins 3 and 2 are connected during FM mode operation).

The coarse tune/loop compensated signal, with FM added if appropriate, is sent to pin 12 of amplifier IC418

and also sent to pin 6 of VCO IC500. IC418 circuitry is used as a difference amplifier to compare the summed signal (coarse tune/loop compensated/FM, if present) at pin 12 (of IC418) with the coarse tune output from pin 1 of IC418 through pins 6 and 7 of IC418. The difference signal at pin 7 of IC418 is sent through Switch IC419 (pin 2 to pin 3) to pin 24 of P401. This is error voltage signal TPX, an analog signal sent to the Control Board for test and calibration purposes. Switch IC419 is enabled by a low at pin 1 from Control Latch IC405.

The coarse tune/loop compensated signal, with FM added if appropriate, sent to pin 6 of VCO IC500 is used to tune and modulate the VCO.

VCO IC500 is actually a small board that fits on the RF Synthesizer Board. The VCO Board contains two VCOs. The BSEL signal at pin 3 selects the VCO to be used. The low band VCO (275-390 MHz) is selected by a low at pin 3. The high band VCO (390-550 MHz) is selected by a high at pin 3. The control signal comes from Control Latch IC405, pin 17.

The VCO Board schematic is shown in Figure 9-7. The function of the VCO Board is to produce an RF signal with a frequency range of 275-550 MHz. The frequency is set by a tuning voltage Vtune. The frequency range is separated into a low band (275-390 MHz) and a high band (390-550 MHz), each provided by a different oscillator. An analog switch selects the oscillator used. The oscillator outputs go through a common buffer amplifier to the VCO Board's output.

The basic active component in the low band oscillator is Transistor Q501, configured as a modified Clapp oscillator. L502 and Varactors CR501-504 form the main resonator. Feedback is provided through capacitors C502-504, Varactor CR505, and emitter resistors R504 and R505. The output obtained from the collector across R502 goes through a low pass filter (L506, C511 and C512) and a PIN Diode CR506 to the buffer amplifier.

The high band oscillator has the same basic design as the low band oscillator, with Q502 the main active component. The main resonant tank consists of L508, CR508 and CR509. The feedback network consists of R516, 517, C522, 524 and CR510-513, with C523 a DC blocking capacitor. Output is obtained from the collector across R514, and goes through a low pass filter (L507, C519 and C520) and PIN diode CR507 to the buffer amplifier.

Band switching is performed by IC501. IC501 is a single-pole, double-throw analog switch controlled by the band select line (BSEL). When BSEL is at a logic "HIGH" level, power is supplied to the high band oscillator and CR507 is also turned on. Similarly, when BSEL is at logic "LOW", power is supplied to the low band oscillator and CR506 is turned on.

IC502 is the Buffer Amplifier. Signals from the two oscillators pass through an attenuator formed by R509, 510, and 511 into amplifier IC502. The output of IC502 goes to the OSC Out to be used by the RF Synthesizer Board.

The VCO output is sent to the RF OUT Jack J501 through a 17 dB attenuator pad (R454, R455, and R456) and a 17 dB amplifier (IC420) to isolate the VCO (from the output load at J501). A sample of the VCO output is applied to pin 2 of amplifier IC421. The output at pin 7 goes through an attenuator pad (R466, R464, and R465) and a high pass filter (C594, L407, and C593) to pin 2 of amplifier IC422. These stages isolate the VCO from the PLL feedback.

The output at pin 7 of IC422 is applied to Divide-by-10 Counter IC416. This device is a Divide-by-10/11 wired as a Divide-by-10. Its counted down output goes to IC410, a divide-by-5/6 counter. IC410, Adder IC409, Counters N_m and A_m in Main PLL chip IC408, and Counters N_a and A_a in Auxiliary PLL chip IC407 comprise the fractional divider network in the PLL feedback circuit.

The modulus control signal from pin 14 of Main PLL chip IC408 to pin 9 of Divide-by-5/6 Counter IC410 determines the part of the total counting time that IC410 divides by 5 and the part of the total counting time that IC410 divides by 6. This modulus control line is itself controlled by Counters N_m and A_m in Main PLL chip IC408. When fractional division is required, Counter A_m must divide by A_m for the part of the counting time and divide by A_m+1 for the remaining part of the counting time (see section 7.7.4, Frequency Synthesis, for greater detail). The four bits from pins 4, 1, 13, and 10 of Adder IC409 to Main PLL chip IC408 determine whether A_m divides by A_m or by A_m+1. These four bits are controlled by the modulus control signal from pin 14 of the Auxiliary PLL chip IC407 to pin 6 of Adder IC409. When this signal is low, A_m divides by A_m. When this signal is high, A_m divides by A_m+1. Counters N_a and A_m in Auxiliary PLL chip IC407 control the signal over the total counting time. (see section 7.7.4, Frequency Synthesis, for greater detail). The data bus (D0-D7) sets the internal conditions for all internal circuitry in the two PLL chips and the Adder chip.

7.7.4 FREQUENCY SYNTHESIS

The RF synthesizer board output frequency, fs, is:

$$fs = 10 \left(N_T + \frac{F}{10}\right) . fR$$

where fR is the reference frequency of the PLL from the Reference Synthesizer Bd.

N_T is the integer frequency division in the feedback, excluding the constant divide-by-10.

F is an integer, specifying the fractional frequency division: F=0 (no fractional division) for the FM mode; 0 ≤ F <10 for the CW mode.

N_T is obtained by the ÷ 5/6 counter (IC410) and the N_m and A_m counters in the Main PLL chip IC408. The total division is:

$$N_T = 5 \cdot N_m + A_m$$

For fractional division to occur, counter A_m must divide by A_m for part of the counting time and divide by A [m+1 for the remaining part of the counting time. Counters N_a and A_a in the Auxiliary PLL chip IC407 determine the A_m/ A_m+1 counting ratio of counter A_m. There are ten (10) intervals in a complete counting cycle. Counter N_a is set at 10, Counter A_a set at 10-F. The Modulus Control output of the Auxiliary PLL (pin 14 of IC407) will be low for 10-F pulses, high for F pulses. When this signal is high, the output of the 4-bit adder (pins 4, 1, 13, and 10 of IC409) is increased by one. The main PLL IC is set (by the data bus) so that its A [in'm'] divider (register) is controlled by the 4-bit Adder output. Therefore, A_m divides by A_m for 10-F pulses and by (A_m+1) for F pulses.

The average division is $(A_m + \frac{F}{10})$.

The total division is $(N_T + \frac{F}{10})$.

7.7.5 VCO POWER FILTERS

Transistors Q402, 403, 404 and 405 and their associated components serve to reduce AC noise on the + and power supply lines to the VCO.

7.8 REFERENCE and LO BOARD

7.8.1 OVERVIEW

Refer to Block Diagram Fig 7-7 (0013-10-0040). Figure 9-8 is the schematic for the Reference and LO (Local Oscillator) Board. This board provides the 10 MHz internal reference source and contains the circuitry that processes the 10 MHz external reference. This board also provides the 10 MHz reference to the DOS Board, the 1 MHz reference to the Reference Synthesizer Board and Control Board, and the 512 MHz L.O. output to the Output Board.

7.8.2 INTERNAL/EXTERNAL REFERENCE SOURCE

The INT/EXT, low, control signal from pin 12 of Control Latch IC604 determines which Switch of Diode Switch pair CR606 and CR607 is closed (and allows signal flow to pass) at any given time. The internal 10 MHz reference comes from pin 2 of Temperature Compensated Crystal TCX0. The signal is applied through Transistor Q606 and passes through Switch CR606 when it is closed by a high at its anode (the INT/EXT, low, signal from Control Latch IC604 through Switch Driver IC612 is high). Coil L606 provides a high impedance path for the 10 MHz signal when CR606 is open, with any signal leak through the coil shorted to ground by C659. The 10 MHz reference at the emitter of Q606 also passes through an attenuator pad (R647, R646, and R645) and is applied to Amplifier IC614. The amplified signal is the Internal Reference Out signal at J603.

The 10 MHz external reference input at J604 passes through an attenuator pad (R648, R649, and R650) and is applied to Switch CR607. It passes through Switch CR607 when it is closed by a low at its cathode (the INT/ EXT, low, signal from Control Latch IC604 through Switch Driver IC612 is low). Coil L605 provides a high impedance path for the 10 MHz external reference signal when CR607 is open, with any signal leak through the coil shorted to ground by C659.

The reference source passed through Diode Switch pair CR606/CR607 goes through another attenuator pad (R639, R640, and R641) to Amplifier IC613. The amplified reference is applied to buffer transistor Q608 and then to pin 7 of Phase Lock Loop (PLL) Synthesizer IC601 and also to pin 3 of P601 (the reference to the DDS Board).

7.8.3 PHASE LOCK LOOP (PLL) SYNTHESIZER

The L.O. (Local Oscillator) consists of a VCO, phase-locked to a reference, by the Phase Lock Loop (PLL) Synthesizer IC601. The VCO output frequency (f_0) from the collector of Transistor Q603 is fed back to pin 2 of divide-by-64 fixed prescaler IC602. The prescaler output frequency (f_d) is then divided by 8 in a divide-by-8 divider in PLL Synthesizer IC601. The output frequency of the divide-by-8 device (f_v) is compared by a PFD (Phase/ Frequency Detector) in the PLL Synthesizer Chip to a 1 MHz fixed frequency (f_R) derived by dividing the input 10 MHz TCXO signal (f_x) at pin 7 by 10. At phase lock:

$$f_v = f_R = 1 \text{ MHz}$$

$$\left(\text{because } f_v = \frac{fo}{64 \times 8} = \frac{fo}{512}\right)$$

then:

$f_0 = 512\ f_R = 512$ MHz

Pin 18 of the PLL Synthesizer Chip provides the 1 MHz reference to the Reference Synth Board and the Control Board (see Section 7.) at pin 5 of P601.

7.8.4 LOOP FILTER AND COMPARATOR CIRCUITS

The PFD outputs at pins 16 and 17 of IC601 are connected to a differential Loop Filter (LF) composed of IC608A and its associated circuitry. The LF output from pin 1 of IC608A drives the VCO tuning circuitry (see Section 7.8.5). The LF output from IC608A also goes to Comparator IC608B. When the Local Oscillator is enabled and the loop is locked, the output at pin 7 will be between 4 V and 10 V An unlocked condition will produce an output at pin 7 less than 4V or greater than 10 V, and generate the LO UNLOCK (UNLOCK2) signal at pin 26 of P601 (sent to the Control Board; see Section 7.4). When the LO output is not used i.e. when the F.P. output frequency is >137.5 MHz, transistor Q601 shunts the LO unlock signal to ground so the microprocessor will not indicate an error condition.

7.8.5 VCO CIRCUITRY

The LF output from pin 1 of IC608A (see Section 7.8.4) is applied through L603 to drive the VCO tuning circuitry. Varactor CR605, C652, the transmission line segment between C652 and R622 (which acts as an inductor), and C653 and C654 form the main resonant tank for the VCO. The tank resonates at 512 MHz, with feedback provided through R624, R625, C653, and C654. Transistor Q603 is the active device for the VCO. Transistors Q605 and Q604 are controlled by the L.O. enable signal from pin 13 of Control Latch IC604 and provide bias for oscillator Q603.

7.8.6 VCO OUTPUT CIRCUIT

The output at the collector of Q603 passes through a low pass filter network (C648, C647, and the inductance in the transmission line segments shown between the two capacitors) and is then applied to pin 1 Amplifier IC605. The output from pin 3 of IC605 is the 512 MHz Local Oscillator output to the Output Board at J602 (see Section 7-11).

The RLC network between the output of IC605 and J602 is a bias decoupling network.

Q609 and 610 and their associated components serve to reduce AC noise on the - supply of the VCO.

7.8.7 CONTROL AND DATA CIRCUITRY

Control logic is provided by Control Latch IC604. Data is processed through Data Latch IC603. ID Buffer IC606 contains board identification (see Section 7.2.2). IC607 is the Decoder. Data bus lines RFD7-RFD0 (pins 8-15 of P601) and SEL2 and Address lines RFA0 and RFA1 (pins 27, 34, and 33 of P601) provide communication to the Control Board.

7.9 DOUBLER BOARD

7.9.1 OVERVIEW

Refer to Figure 9-9 and block diagram fig 7-5 (0013-10-0038) for the following discussion. The Doubler board takes the 275-550 MHz RF signal from the RF Synthesizer Board (see section 7.7) and sends it through frequency doubler circuitry to obtain the additional 550-1100 MHz range. In addition, the board contains a switched filter bank, amplification and leveling circuits and control circuits.

7.9.2 RF AND LEVELING CIRCUITS

The RF input from the RF synthesizer board is applied at J1500. The 275-550 MHz input signal has a level of 0 dBm ± 3 dB. The signal is amplified by IC1500 and applied to a frequency doubler (G1500) or an attenuator (R1508-R1512), depending on the control signal F. For positive F, CR1501 and CR1503 will be on and the attenuator will be selected; for negative F, CR1500 and CR1502 will be on and the doubler will be selected.

The combined signal at C1508 has a frequency range from 275-1100 MHz and is applied to an amplifier (IC1501) and then to a switched filter bank FL1500 (three band pass filters and a thru filter) according to the selection signals shown in Table 7-4.

TABLE 7-4. BANK SELECTION SIGNALS

Freq Range (MHz)	Control F	Control D1	Signals D2	Signals D3	Filter Selected
275-550	+	-	-	-	Thru
550-693	-	+	-	-	BPF1
693-873	-	-	+	-	BPF2
873-1100	-	-	-	+	BPF3

The switched filter bank output is amplified (IC1512) and then applied to a variable PIN diode attenuator

(CR1504, R1522, R1523) and another amplifier (IC1502). The output of IC1502 is connected to the output connector J1501 through R1537. The output of IC1502 is detected by CR1505, for which CR1506 provides temperature compensation and DC offset. The detected signal is compared to a reference set by a voltage divider (R1528, R1529) of the + 15 V supply to set the output level of 0 dBm (±3 dB). The comparison is performed by one half of IC1511. The other half of IC1511 is the integrator for the leveler loop, the output of which drives the PIN diode attenuator described earlier.

7.9.3 DIGITAL INTERFACE, CONTROL AND INDICATION CIRCUITS

Decoder IC1503 selects the ID Buffer (IC1504) or the Control Latch (IC1505) to interface with the data bus. The Control Latch drives four amplifiers (connected as comparators, IC1509) which each drive an NPN-PNP transistor pair to generate the control signals F, D1, D2, and D3. The Latch also drives an analog switch (IC1510) which selects one of two test points, coming from the leveler feedback circuitry, to be output as a TPX indication.

7.10 AM/DIVIDER BOARD

7.10.1 OVERVIEW

Refer to Figure 9-10 and Block Diagram Fig 7-6 (0013-10-0039) for the following discussion. The AM/DIV board takes the 275-1100 MHz RF signal from the Doubler Board (see section 7.9) and sends it through either no conversion or through frequency conversion circuitry (to obtain the additional 137.5 to 275 MHz range). This circuitry also reduces harmonic content.

The signal then goes through a chain of variable attenuators, amplifiers and a level detector to set the output power level and to allow amplitude modulation (AM). AM is achieved by comparing the level detector output with the modulation signal at AM REF IN, and using the difference voltage as a negative feedback to control the variable attenuators. This system produces an output amplitude that varies directly with the modulation signal.

7.10.2 SIGNAL PATHWAYS

There are five separate paths the RF IN signal at J700 can take, depending upon the desired output frequency, and the microprocessor band switch control network that determines the path the signal will take.

The first of the five pathways the RF In signal can take is the 550-1100 MHz circuit. The input 550-1100 MHz signal is passed unchanged through the resistor/ diode string from CR700 to C703 and into the variable attenuator PIN diode circuitry of CR729 and CR730.

The four remaining signal pathways receive a 275-550 MHz input from the Doubler Board. These paths consist of two straight through, no conversion circuits (one for 390-550 MHz signals, one for 275-390 MHz signals) and two divide-by-two circuits (one for 195-275 MHz signals, one for 137.5-195 MHz signals).

Signal paths 1-3 are non-conversion routes. Signal path 1 (550-1100 MHz) begins through diode CR700 to resistor R700. Path 2 begins through CR701 and CR727. Path 3 begins through diodes CR704 and CR705. Signal path 4 and 5 begin through diodes CR704 and CR707 and go through C722 to pin 7 of divide-by-two frequency divider IC700. The divided output at pin 2 will then go through the low pass filter string beginning at C729/L710 (path 4; 195-275 MHz) or beginning at C736/L714 (path 5; 137.5-195 MHz).

The RF signal in at J700 is applied simultaneously to each path described above. Only one path will be opened (turned on). The actual path the signal takes will be determined by the band switching control signals from the microprocessor on data bus lines RFD0-RFD7. These are fed to Data Control Latch IC712 and transferred to Buffer IC711. The buffered signals, H0 and F1-F4, turn on/off the bandswitch diodes and the frequency divider. Output circuitry (transistors Q701 and Q702) further processes the F3 and F4 control signals.

The band switching signals turn on diodes (and other components in paths 4 and 5) to allow signal flow. Band switching signals are positive logic (1 = 5 volts), with all lines active high. The frequencies, control signals, and bandswitch diodes associated with each path are shown in Table 7-5.

All of the low pass filters used in the frequency conversion pathways are of the same design. They are ninth order Tschebyshev filters, consisting of four series inductors and five shunt capacitors.

The frequency divider is an ECL flip-flop (IC700) connected as a divide-by-two circuit. The divider converts the input frequency range of 275-550 MHz into an output frequency range of 137.5-275 MHz. Power is applied to the divider through 5 V Voltage Regulator IC701 when either F3 or F4 is turned on.

TABLE 7-5. RF SIGNAL PATH INFORMATION

PATH	OUTPUT FREQ.	INPUT FREQ.	CONTROL SIGNAL	SW DIODES
1	550-1100 MHz	SAME	H0	CR 700,728,702
2	390-549.999999	"	F1	CR 701,727,703
3	275-389.999999	"	F2	CR 704,705,715,706
4	195-274.999999	390 - 550	F3	CR 704,707,711,712,708
5	137.5-194.999999	275 - 390	F4	CR 704,707,713,714,708

The output from each of the five frequency conversion paths goes through C703 and is applied to variable attenuator PIN diodes CR729 and CR730.

7.10.3 Leveler/AM Range Control

The leveler section includes two stages of variable attenuation. The first variable attenuator consists of PIN diodes CR729 and CR730, and their bias resistors and decoupling capacitors. The second attenuator consists of CR731 and CR732 and their bias network. Two stages of variable attenuation are required to provide leveling and to provide the amplitude modulation (AM) range control.

The PIN diode attenuators are driven through transistors Q700 and Q703 by the output at pin 1 of Comparator IC705B. The Comparator compares the linearized detected output (see the following sections) with the AM drive reference from pin 5 of P700 from the Control Board (see section 7.4). Transistors Q703 and Q700 function as buffer stages that control the current through PIN diodes CR729, CR730, CR731, and CR732 RF signal level.

A feedback system is used to achieve level control. The RF output to J701 is detected by two Schottky diodes CR722 & CR723 acting as full wave rectifiers. Their outputs are combined in Operational Amplifier IC706A. Diode CR724 provides temperature compensation for the rectifiers. Potentiometer R750 is used to nullify the offset voltage at the output of IC706A (TP 1).

The detector output is linearized by summing the output of IC706A with the voltage drop across another diode of the same type as the detector. Using the voltage drop from a diode of the same type as the detector corrects for the non-linear behavior of the detector at low RF levels. This voltage drop is provided by CR726, R761 and IC706B. Diode CR725 prevents saturation of IC706B by a positive offset voltage at TP1. The output of IC706A and the voltage drop across the diode are summed in Op Amp IC705A. Potentiometer R776 adjusts the offset voltage at TP2 to zero.

Comparator IC705B compares the linearized detector output from IC705A with the AM reference voltage. The difference is integrated in IC705B to form a type-one system where tracking error approaches zero with the increase of time. The resultant error signal at pin 1 of IC705B is applied to the base of transistor Q703, producing a voltage change that controls the current through PIN diodes CR729 and CR730. The error signal at pin 1 of IC705B also is applied to the base of transistor Q700, producing a voltage change that controls the current through PIN diodes CR731 and CR732. Transistors Q700 & Q703 form emitter followers to increase the current drive ability for IC705B to drive the two variable attenuators. R779 (connected to pin 2 of IC705B) determines the nominal RF output level and resistors R773, R770, R765, and R779 determine AM accuracy.

The error signal at pin 1 of IC705B also is fed to pins 10 Switch IC707 to be output to the Control Board as test signal TPX (pin 24 of P700) if that section of the switch is enabled (see section 7.10.4).

Amplitude modulation is achieved by superimposing a modulation signal on top of the DC level reference voltage in the AM drive signal. The amplitude of the RF out signal will track the AM input.

Two types of amplifiers are used to amplify the RF signal. IC715, IC702, and IC703 are small signal amplifiers. Output stage amplifier IC704 is a medium level amplifier.

Roll-off compensation consists of a series tank (L747 and C811) that resonates at 1 GHz across resistor R794 and also the shunt arms of resistors R793 & R795 in series with L745 and L746, respectively. This circuit attenuates the signal at low frequencies to compensate for roll-off in the amplifier and detector circuits.

7.10.4 Digital Interface and Analog Feedback Circuits

Decoder IC709 decodes the digital interface signals (Address bus lines RFA0-RFA3 and SEL 1) that select the AM/Divider board (SEL 1, low) and then select the various devices on the board. ID Buffer IC710 returns the code for AM/Divider board identification (see section 7.2.2) to the microprocessor. Data Control Latch IC712

latches the control information from data lines RFD0-RFD7. IC711 shifts the control signals to proper voltage levels for band switching and controls the various switches in Switch IC707. Switch IC707 operation is identical to that described for quad switches IC237 and IC238 in section 7.4.2, with control signals at pins 1, 8, and 9 opening and closing the internal switches. Switch IC707 selects between Test Points 1, 2, and 3 inputs (at pins 2, 7, and 10, respectively) and sends the selected signal to pin 24 of P700 as signal TPX. This signal is then sent to the Control Board for diagnostic and calibration purposes (see section 7.4).

7.10.5 BYPASS CAPACITORS

The capacitor string (C776-C787; lower left corner of schematic) are bypass capacitors.

7.11 OUTPUT BOARD

7.11.1 OVERVIEW

Refer to Block Diagram Fig 7-9 (0013-10-0042). Figures 9-11 and 9-12 are the schematics for the Output Board. The Output Board provides the main RF output to the attenuator, with vernier level control and DC AM. The Output Board extends the AM/Divider Board's output signal (see Section 7.10) down to 10 kHz by mixing it with the local oscillator input (512 MHz) from the LO/REF Board (see Section 7.8). The Output Board also provides a buffered Auxiliary Output (AUX OUT) .

The Output Board contains an input buffer, a straight through path, an auxiliary output path, two heterodyne paths, a leveler, and an output amplifier. The RF signals are switched through these different sections, and through two different variable gain blocks in the leveler section, depending on the desired output frequency.

7.11.2 INPUT BUFFER

The RF signal coming in from the AM/DIV Board at J800 (Figure 9-11) goes through a fixed attenuator (pad R800, R801, and R802) and a buffer amplifier (IC801) for isolation. The buffered signal is switched into different paths depending on the desired output frequency. The three signal paths are shown in Table 7-6, with their associated input/output frequencies, control signals, and control switches.

7.11.3 STRAIGHT THROUGH PATH AND AUX OUT PATH

When the output frequency is greater than 137.5 MHz (shown as the THRU Band in Table 7-6), the RF signal from buffer/amplifier IC801 is switched through control diodes CR801-CR804 and additional attenuation, and split between two paths after R845. Part of the signal power goes to amplifier (IC804) and the AUX OUT connector at J802. The rest of the signal power goes to the straight through (THRU) path that begins on Figure 9-11 and ends on Figure 9-12. ON Figure 9-11, the signal goes through variable attenuators (PIN diodes CR811 and CR812) and amplifier IC803 and is output as signal AA to Figure 9-12. The GAIN CONTROL input to R864 (and PIN diodes CR811 and CR812) in the THRU path on Figure 9-11 is from the Leveler circuitry (see Section 7.11.5). The THRU path on Figure 9-12 is through variable attenuators (PIN diodes CR815 and CR816) and buffer amplifier IC805, through PIN diode switch CR821 into amplifier IC809. This amplifier and the circuitry following it are common to all signal paths on the Output Board. The GAIN CONTROL input to R924 (and the PIN diodes) is from the Leveler circuitry (see Section 7.11.5).

7.11.4 THE MIXER AND HETERODYNED BANDS

The frequency range below 137.5 MHz is produced by two heterodyned bands, HET1 (10 MHz to 137.5 MHz) and HET2 (10 kHz to 10 MHz). When either of these bands is selected, the input RF signal at J800 (Figure 9-11) passes through amplifier IC801 and is switched by control switch CR800 through a fixed attenuator (pad R808, R809, and R810) into mixer MX800. In the mixer, this signal beats against a 512 MHz signal from the LO IN connector (J801) to produce the desired output frequency at the IF port of the mixer. The 512 MHz LO IN signal goes through a fixed attenuator (pad R806, R825, and R807) and a buffer amplifier (IC800) for isolation.

The IF signal from the mixer is passed into a Diplexor (R813, R814, L802, and C808) and a 150 MHz Low Pass Filter (C812, L804, and C814) where all unwanted signals above 150 MHz are blocked without being reflected into the mixer. The signal then goes through Broadband Amplifier IC802 and another Low Pass Filter (C829, L813, and C834).

If the HET1 path (10 MHz to 137.5 MHz output frequency) is selected, the signal passes through PIN diode switch CR810 to R845 and is split between the THRU and AUX OUT paths (see section 7.11.3). CR810 is controlled by the F67A signal at R816.

If the HET2 path (10 kHz to 10 MHz) is selected, then a portion of the signal power also goes through FET Switch Q800 into a variable gain amplifier composed of Dual Gate FET Q804 and Transistors Q801 and Q803. The GAIN CONTROL input to R839 (and to G2 of Q804) is from the Leveler circuitry (see Section 7.11.5). The output through FET Switch Q802 is applied as

signal BB to Amplifier IC809 (Figure 9-12). Control signal F7 opens and closes the two FET Switches (Q800 and Q802) in the HET2 path.

7.11.5 LEVELER

Variable gain for signals with frequency above 10 MHz is provided separate to that for signals with frequency below 10 MHz. PIN diode variable attenuators CR811 and CR812 associated with amplifier IC803 and PIN diode variable attenuators CR815 and CR816 associated with amplifier IC805 provide the variable gain for signals above 10 MHz. The variable gain amplifier composed of Amplifiers Q804, Q801, and Q803 provides the variable gain for signals below 10 MHz.

The signal from the THRU path or the HET1 path or the HET2 path goes through two stages of amplification (Amplifiers IC809 and IC810; Figure 9-12) and then to the detector circuit. Diodes CR817 and CR818 are the detectors. Their outputs go to pins 2 and 3 of Summing Amplifier IC806. The output at pin 1 is applied to the other half of IC806. The circuitry associated with this half (pins 5, 6, and 7) of IC806 forms a linearization circuit for the detected output. Temperature compensation is provided by CR819. The linearized output at pin 7 is applied to pin 2 of Comparator IC808 and is then compared to the Level Reference Input (LEV REF) at R905 from pin 3 of J804 (Figure 9-11). The difference voltage at pin 1 of IC808 is integrated and used as a negative feedback (GAIN CONTROL signals) to control either the variable gain amplifier or the variable PIN diode attenuators. Vernier level control and DC AM is achieved because the RF power level coming through the detector varies directly with the LEV REF input.

The linearized detector output at pin 7 of IC806 may be applied through Switch IC807 (pin 11) as test signal TPX to pin 24 of J804 (Figure 9-11). The DET TEST low output at pin 12 of Command Code Latch IC900 is applied to pin 9 of Switch IC807 (Figure 9-12) to close the switch. The GAIN CONTROL signal at the emitter of Transistor Q808 (Figure 9-12) may be applied through pin 14 of Switch IC807 as test signal TPX to pin 24 of J804 (Figure 9-11). The PIN TEST low output at pin 13 of Command Code Latch IC900 is applied to pin 16 of Switch IC807 (Figure 9-12) to close the switch.

7.11.6 OUTPUT AMPLIFIER

Two stages of output amplification (IC811 and IC812) bring the RF power to the required level at the MAIN OUT connector (J805). The high gain at low frequencies of IC812 is compensated by R940 and C905. R919 and C900 compensate for the high frequency roll off at both stages.

7.11.7 CONTROL LOGIC CIRCUITRY

Control logic is provided by Command Code Latch IC900 (Figure 9-11) and Buffer IC903. Buffer IC903 provides proper level signals to Control Signal Drivers Q904, Q906-Q909. ID Buffer IC901 contains board identification (see Section 7.2.2). IC902 is the Decoder. Data bus lines RFD7-RFD0 (pins 8-15 of J804) and SEL3 (low) and Address lines RFA3-RFA0 (pins 27, 30, and 32-34 of J804) provide communication to the Microprocessor Board through the Control Board.

7.12 MOTHERBOARD

7.12.1 OVERVIEW

Figure 9-13 is the schematic for the Motherboard. Refer also to Fig 7-1 (0013-20-0006). The various boards used in the 2405/2410A fit into slots identified by board name on the Motherboard schematic. The Motherboard provides bus lines and other interconnections that run between these boards. The Motherboard also contains the LCD backlighting circuitry.

TABLE 7-6 RF SIGNAL PATH SUMMARY

BAND	OUTPUT FREQUENCY	INPUT FREQUENCY	CONTROL SIGNAL ACTIVE	SWITCH ACTIVE
THRU	>137.5 MHz	Same	F5, F56	CR801-804, CR821
HET1	10 - 137.5 MHz	502 - 374.5 MHz	F56, F67	CR800, CR821 CR810
HET2	10 kHz - 10 MHz	511.99 - 502 MHz	F67, F7	CR800, CR810, Q800, Q802

7.12.2 BOARD INTERCONNECTION

The data and address bus lines and other interconnections that run between the boards are clearly labeled on Figure 9-13. The jacks at which connections are made for each board and their associated pins are also clearly identified. Note that there is one slot reserved for option boards.

7.12.3 LCD BACKLIGHTING

The EL Inverter E1001 provides the backlight source for the LCD (Liquid Crystal Display). The +5 V IN is converted to a 100 VAC, 400 Hz, OUT to pin 1 of J1014 on the Motherboard. The 100 VAC drives the display backlighting.

7.13 DISPLAY BOARD AND KEYBOARD

7.13.1 OVERVIEW

The Display Board used in the 2405/2410A includes the LCD (Liquid Crystal Display), four LCD drivers and a Controller/Driver. Instruction and Data Registers, Address Counters, and a Display Data RAM are contained inside the Controller/Driver. The RAM stores data in 8-bit character codes.

7.13.2 LCD/COMMUNICATION MICROPROCESSOR INTERACTION

Data and control signals go from the communication microprocessor (IC121 of Figure 9-2) to the LCD through connectors shown on Figure 9-14, the Keyboard schematic. Data lines from the microprocessor pass through pins 1-8 (AD7-AD0) of J1111 to Pins 14-7 of P1112 to the LCD. Control signal RS (pin 12 of J1111) is the register select to the LCD (pin 4 of P1112). Control signal READ (pin 13 of J1111) provides the read/write signal to the LCD (pin 5 of P1112). Control signal STOBE (pin 14 of J1111) is the LCD enable (pin 6 of P1112. Control signal VO (pin 16 of J1111) is the LCD contrast control voltage (pin 3 of P1112).

7.13.3 KEYBOARD CIRCUITRY

When a keyboard switch is pressed, the keyboard interrupt request (INTKEY, low) is generated and the communication microprocessor (IC121 on Figure 9-2) initiates the data exchange necessary to identify the particular key that generated the request for service. Decode process components are found on two schematics, the Keyboard schematic (Figure 9-14) and Microprocessor Board schematic Figure 9-2.

During operation between keyboard use, the communication microprocessor sets a logic "0" (low; o volts) at the "Row 0" to "Row 5" pins (26, 28, 30, 32, 34, and 36) of J1111 (Figure 9-14). The voltage at the "COL 0" to "COL 7" pins (25, 27, 29, 31, 33, 35, 37, and 39) of J1111 is a logic "1" (high; +5 volts) because these pins connect through pins 9C-16C of P102 (Figure 9-2) to +5 volts at pull-up resistor network R180-R187. Pressing any keyboard switch (key) closes the switch and connects its associated Column (COL, odd numbered pins 25-39 of J1111; Figure 9-13) to the low in the Row (ROW, even numbered pins 26-36 of J1111) in which the pressed switch is located. The low at the column is fed through J1111 to the associated pin input to NAND gate IC129 (Figure 9-2) where it generates a high output at pin 8 of IC129. This signal is the INTKEY low that tells the communication microprocessor (IC121, Figure 9-2) the keyboard requires service.

Following a keyboard interrupt, the communication microprocessor will read the column output to determine which column is low. This is the column in which the pressed key is located. Then the microprocessor will write a low (zero) to that column (the other columns will be high). The closed switch in the column will pass the low from the microprocessor into the row in which the switch is located. The microprocessor will read the row outputs and identify the row with the low output (the rows in which no key has been pressed will have high outs). Finally, the microprocessor will compare the column/row information with the 8x6 switch matrix (table) stored in memory to determine which key was pressed, and proceed accordingly.

If the STR key (switch SW1123 in column 4) is pressed, the microprocessor will receive the keyboard interrupt and then locate the pressed key in the following manner. The microprocessor will read the column outputs, identifying column 4 (pin 33 of J1111) as low. The microprocessor will then write a low to column 4 and read the row outputs at J1111. Switch 1123 (STR) will be closed so the low at its pin 1 will be passed to its pin 2 and out to the row 4 output at pin 34 of J1111. The microprocessor will at column 4 and row 4 of the switch matrix, and initiate execution of the STR (store) function.

7.14 POWER SUPPLY

The Model 2405/2410A Power Supply (see Figure 9-15) provides the DC power for the instrument circuitry and fan. AC input power passes through a line filter and then through either a 1 amp or 0.5 amp fuse, depending upon the input voltage source. Input power is then routed through the power switch to the primary of transformer T1300.

The instrument will operate from a 100 VAC, 115 VAC, 215 VAC, or 230 VAC source. The voltage selection wheel in the rear panel AC power connector module

(see Figure 2-1) must be rotated to show the proper input voltage through the small window in the module (the module's full cover must be removed to rotate the selector wheel).

The voltage selector wheel opens and closes the switches associated with the primary of T1300 as shown in the Line Voltage Selector table on the power supply schematic (Figure 9-15) to configure the transformer primary as required. When a 115 VAC source is selected, for example, switches G, I, and J are closed, as shown in the table. Switches H and K are open. Each of the two primary windings are in parallel across the ""voltage in" lines (at points F and B). When a 230 VAC source is selected the primary windings are configured in series.

The secondary of T1300 has five taps; the center tap is grounded.

CR1300 is a bridge rectifier providing full wave rectification of the signal across the secondary of T1300. Each half of the input cycle charges capacitor C1300 to provide a +27 VDC level at the collector of voltage regulator Q1301. Each half of the input cycle also charges C1306 to put a -27 VDC level at the emitter of voltage regulator Q1303.

The +18 VDC at pins 1 and 2 of J1302 is produced by +18 VDC regulator Q1301 which is controlled by its base voltage. Voltage reference IC1300 provides +5 VDC to pin 3 of operational amplifier IC1301. When the +18 volt regulator (Q1301) is at +18 V, voltage divider network R1303 and R1316 feeds a +5 volt level back to pin 2 of IC1301. If the voltage out from the regulator drops, the voltage output at pin 1 of IC1301 increases in response to the decrease in input signal at pin 2. The output at pin 1 of IC1301 is applied to the base of regulator Q1301. When base voltage increases, emitter voltage increases, and the +18 volt supply returns to +18 volts.

FET Q1300 is a current source, supplying current to R1302 to raise the control voltage to the base of Q1301 as needed. This circuit supplies base current to Q1301 to make certain that the regulator will start up when power is applied. Diode CR1302 provides protection for electrolytic capacitor C1302 (prevents a negative voltage at pin 1 or pin 2 being fed to the capacitor).

The -18 VDC at pins 3 and 4 of J1302 is produced by -18 V regulator Q1303 which is controlled by its base voltage. The output from pin 7 of op amp IC1301 controls transistor Q1302 which controls the -18 V regulator. Op amp IC1301 receives a ground (zero volt) reference input at pin 5. The voltage divider network of R1305 and R1307 (from + 18 V to -18 V) sets the other input (pin 6) to zero (0) volts when the -18 V (and +18 V) levels are accurate. If the -18 volt output goes lower (to -17 volts, for example), the input at pin 6 of IC1301 will go positive, forcing pin 7 negative. The negative will be applied to the base of Q1302 which will turn Q1302 on harder. When Q1302 conducts harder, more base current is drawn from regulator Q1303 and the output voltage goes back to -18 volts.

Diode CR1304 provides protection for electrolytic capacitor C1308, preventing a positive voltage at pin 3 or pin 4 being fed to the capacitor.

The voltages fed through diodes CR1305 and CR1306 to C1309 provide an unregulated +12.4 volts to the collector of Darlington power transistor Q1304. R1312 and CR1307 make up a 12 V Zener voltage source applied to the base of Q1304. The two diode voltage drop (approximately 0.6 volts per diode; two diodes in Q1304) of 1.2 volts lowers the +12 volt input to a +10.8 volt level to the fan (J1301, pin 1). The +10.8 volts results in a longer operating life for the fan and quieter operation.

The +8 volt supply at pins 5 and 6 of J1302 is produced by +8 volt three terminal voltage regulator IC1302. The +12.4 volts input (from CR1305 and CR1306) is regulated to an +8 volts output using output feedback through the resistor network of R1313 and R1314 and capacitors C1310 and C1311.

Diode CR1309 protects the regulator from a negative input at pins 5 or 6 of J1302.

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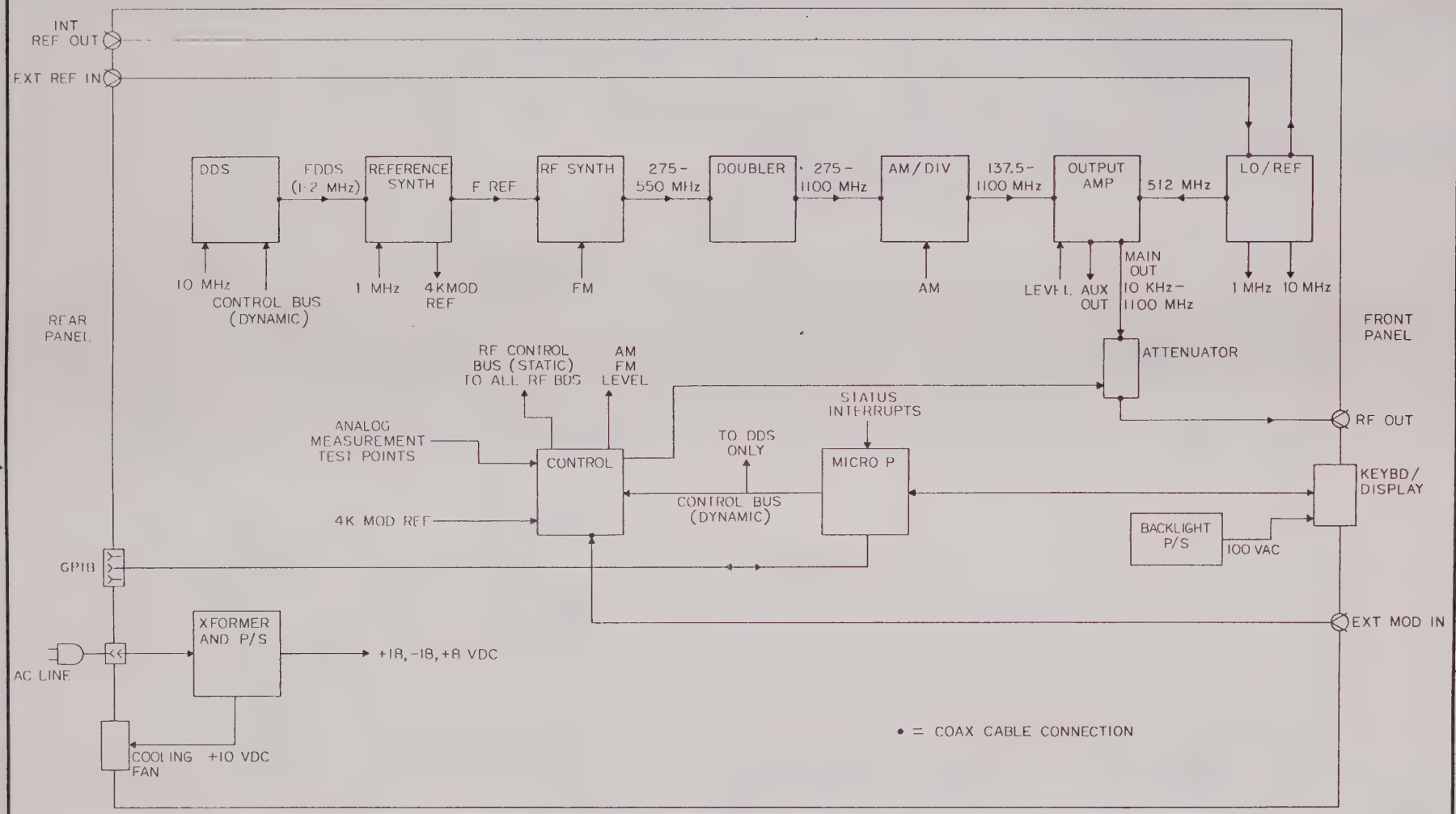

NOTE UNLESS OTHERWISE SPECIFIED

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MATERIAL	PROJ ENGR	5/21/90	TITLE 2410A OVERALL BLOCK DIAGRAM
FINISH WAVETEK PROCESS	RELEASE APPROV	9/14/90	
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX N/A ANGLES XX N/A		
	DO NOT SCALE DWG		MODEL NO
	SCALE NONE		DWG NO 0013-20-0006 REV A
			CODE IDENT 34280 SHEET 1 OF 1

0013-20-0006 A

REVISIONS				
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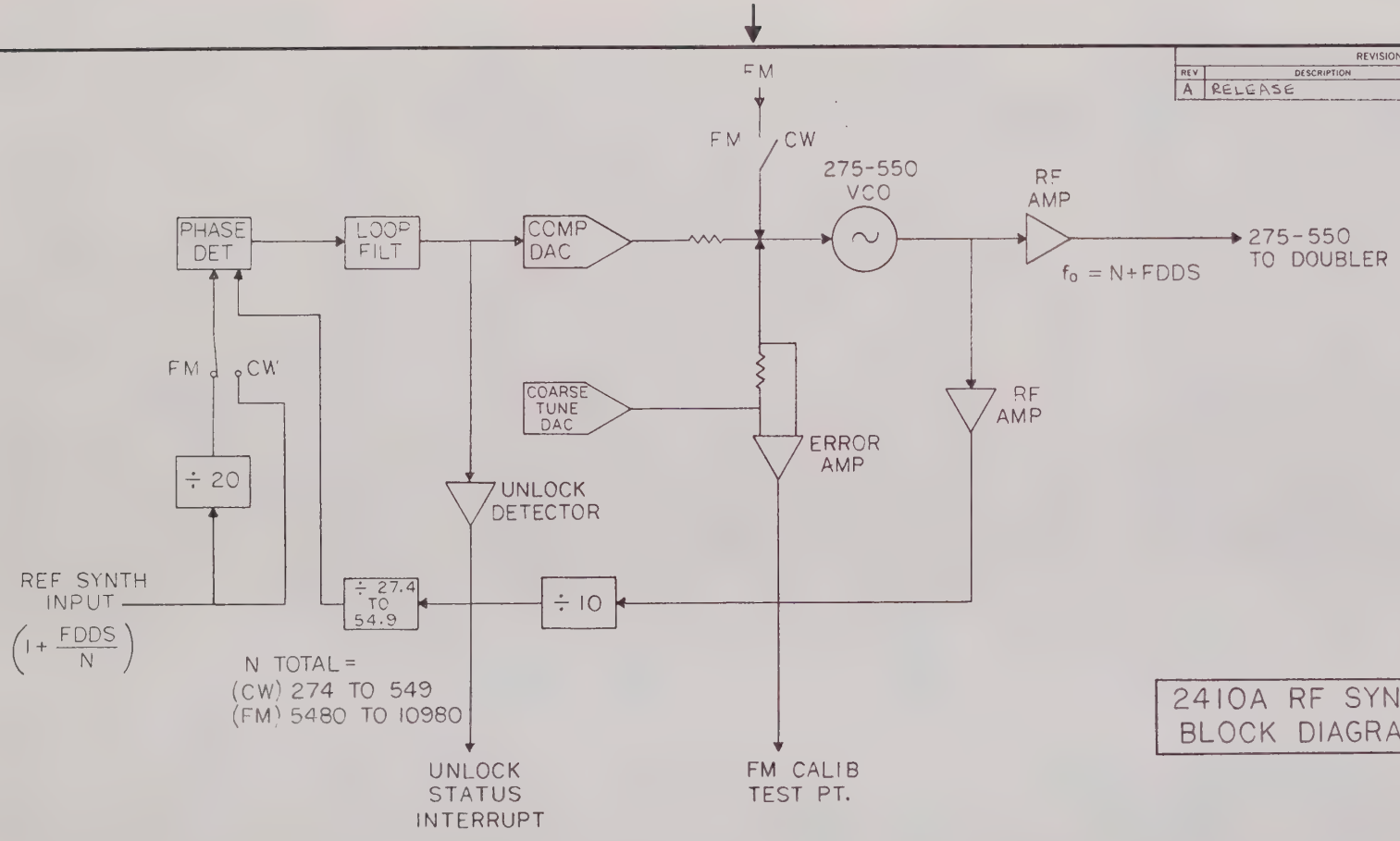

2410A RF SYNTH
BLOCK DIAGRAM

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	APPROVALS / DATE	"This document contains information proprietary to Wavetek. The information in this document is not to be used or duplicated in any manner without the prior approval in writing of Wavetek."	
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TELEDYNE POST N246JB

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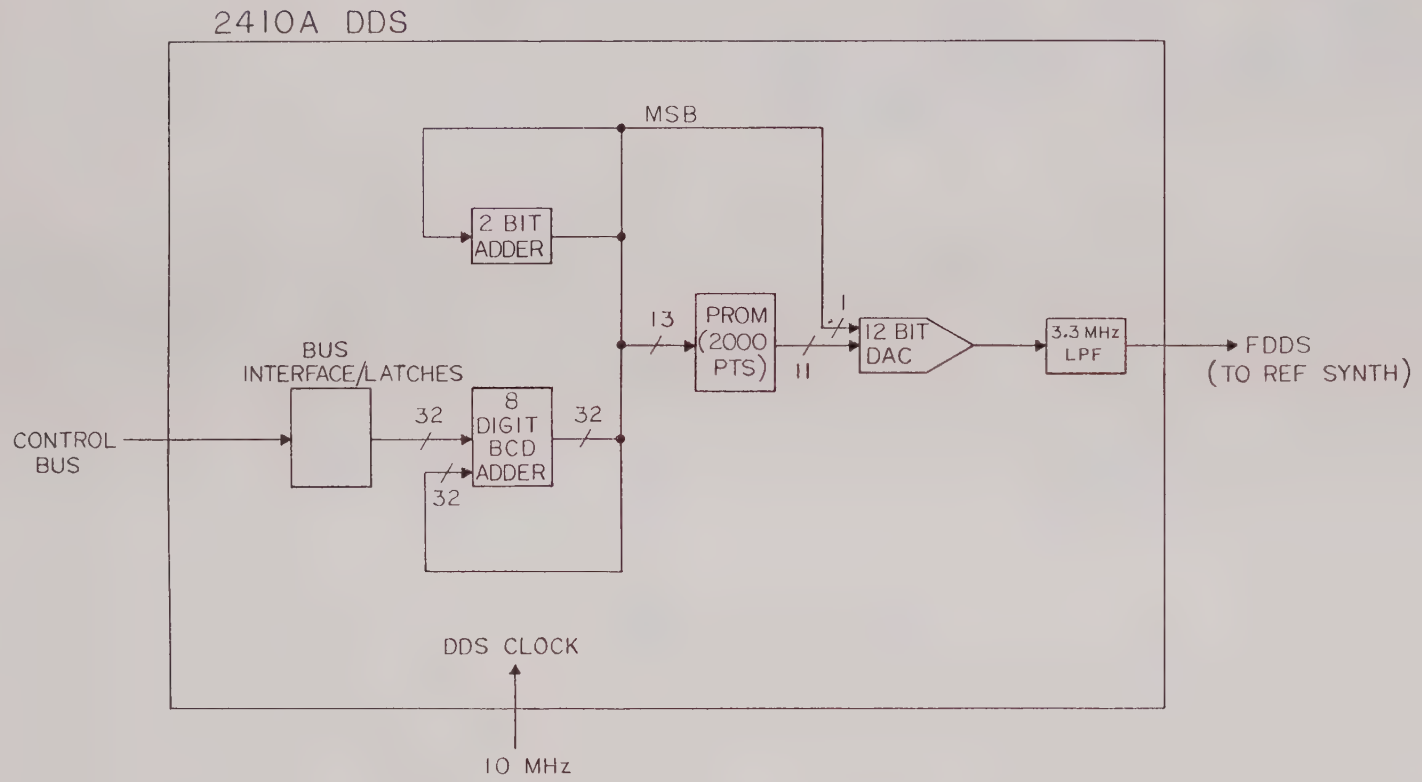

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CONTRACT NO.

APPROVALS	DATE
DRAWN Tim Baer	5/14/90
CHECKED	5/17/90

REV A

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2410A DDS BLOCK DIAGRAM

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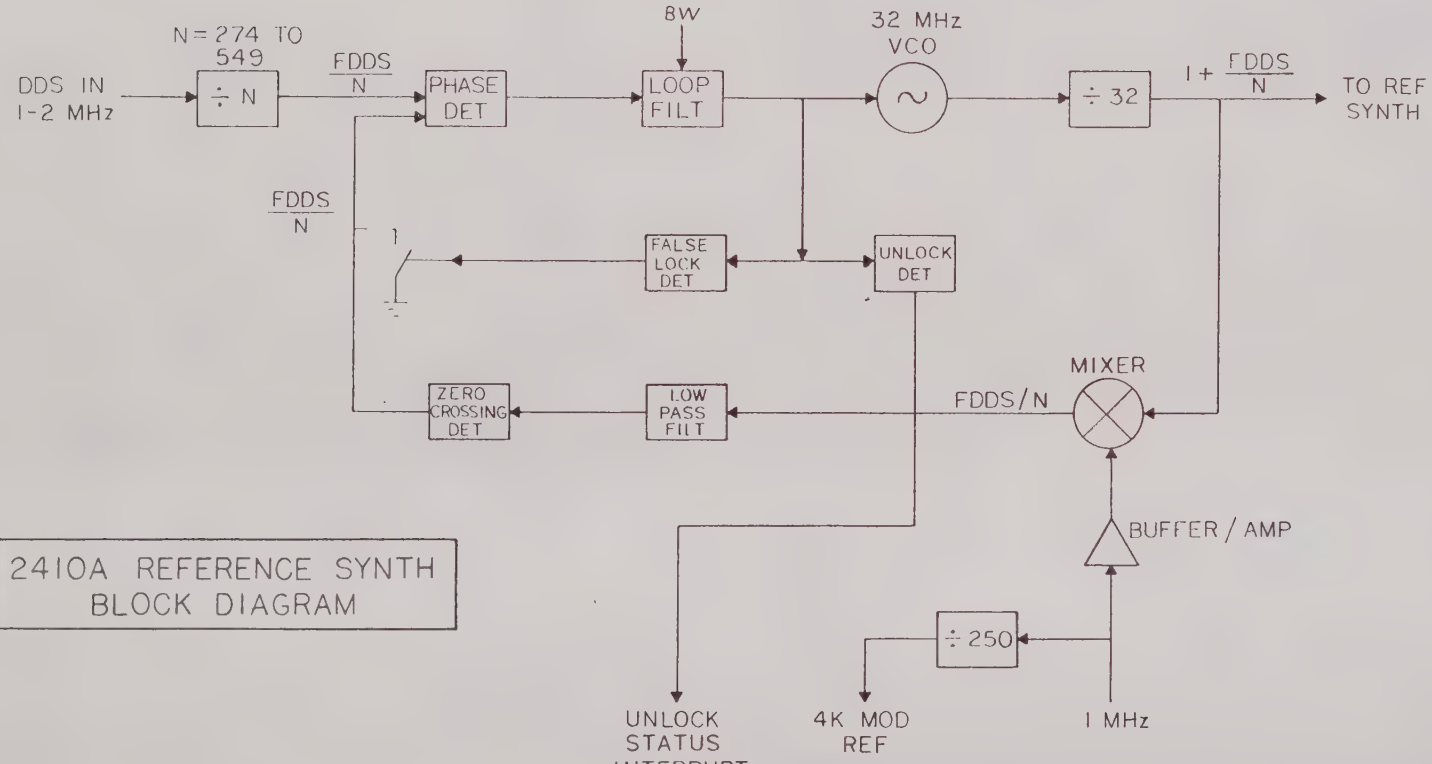

2410A REFERENCE SYNTH BLOCK DIAGRAM

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APPLICATION	

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MATERIAL

FINISH

CONTRACT NO.

APPROVALS	DATE
DRAWN Tim Reed	5/14/90
CHECKED EG	5/21/90

REV A

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2410A REFERENCE SYNTH BLOCK DIAGRAM

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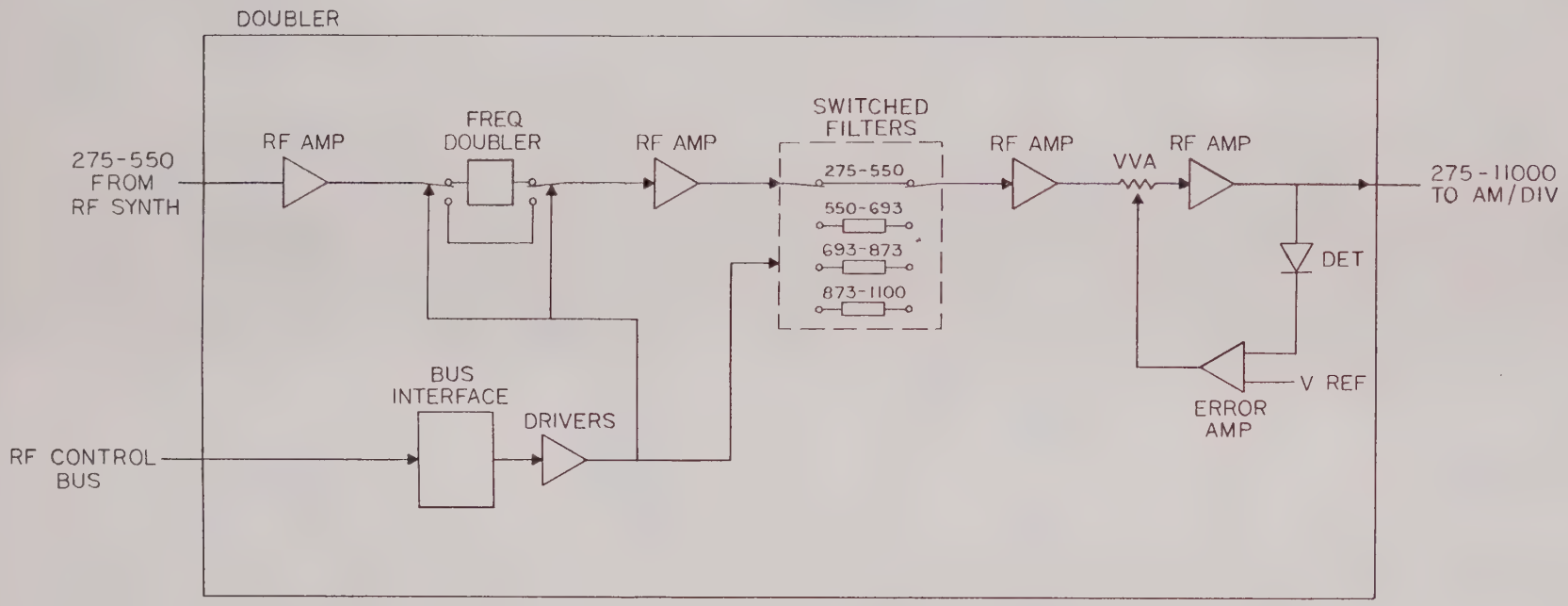

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NEXT ASSY / USED ON	
APPLICATION	

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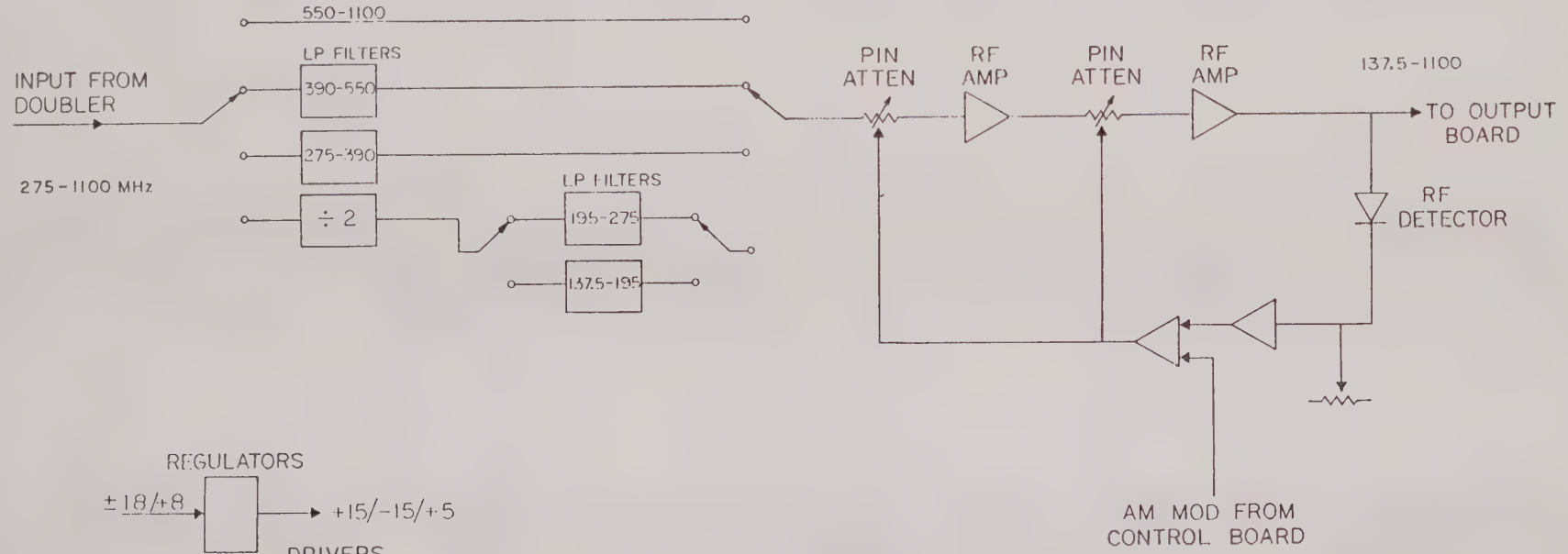
2410/10A DOUBLER
BLOCK DIAGRAM

SIZE	CODE IDENT NO.	DRAWING NO.
B	34280	0013-10-0038

SCALE NONE | DO NOT SCALE DRAWING | SHEET / OF /

AM / DIVIDER BLOCK DIAGRAM

REVISIONS				
REV	DESCRIPTION	BY	DATE	PIN
A	RELEASE	LC	10/12/92	4938



NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ARE:
FRACTIONS DECIMALS ANGLES
± N/A .XX ± N/A ± .XXX ±

CONTRACT NO.

MATERIAL

FINISH

APPROVALS	DATE
DRAWN Tim Baker	5/15/90
CHECKED	5/15/90

REV A

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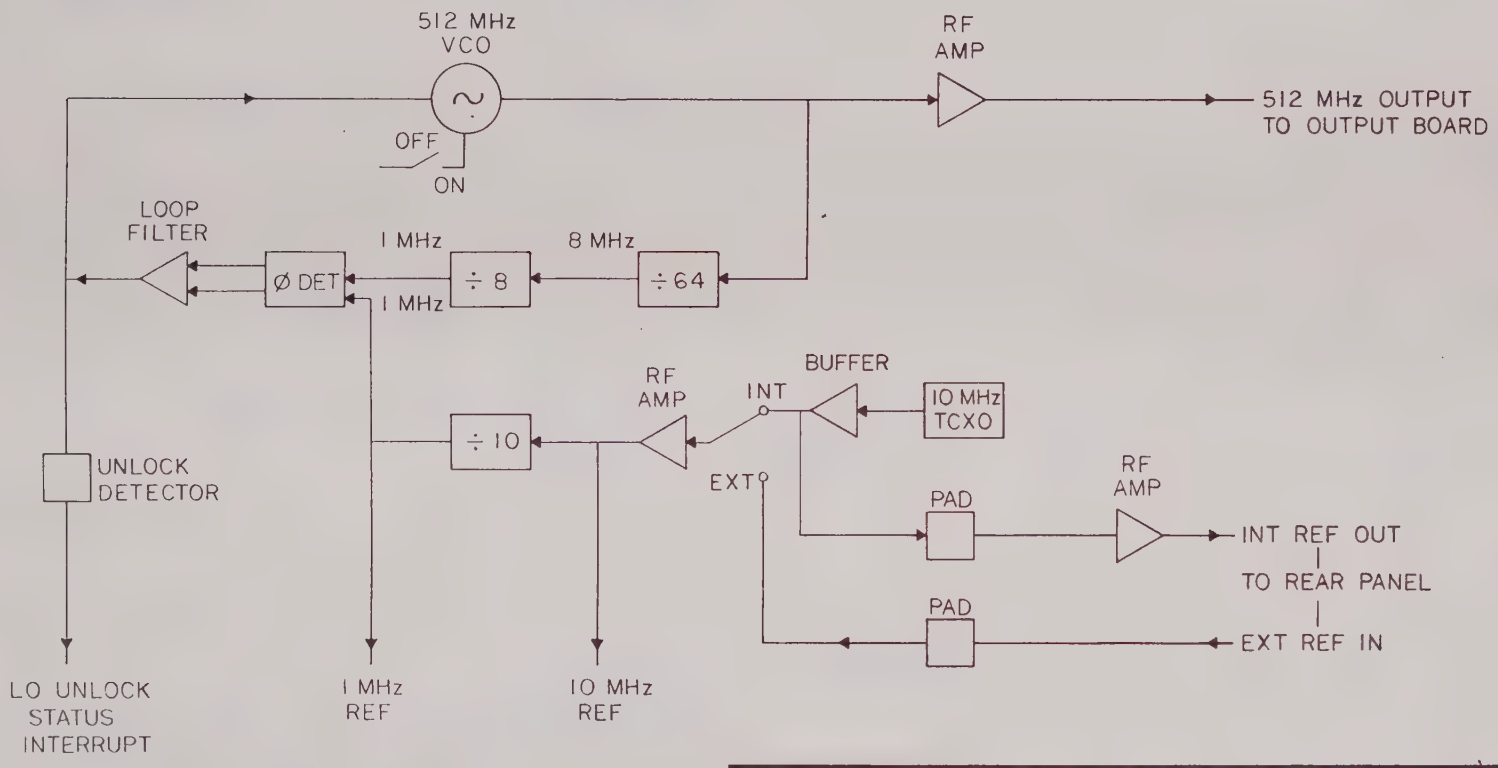
24XX AM/DIV BLOCK DIAGRAM

SIZE	CODE IDENT NO.	DRAWING NO.
B	34280	0013-10-0039

SCALE NONE | DO NOT SCALE DRAWING | SHEET / OF /

LO / REF BLOCK DIAGRAM

REVISIONS				
REV	DESCRIPTION	BY	DATE	PIN
A	RELEASE	EG	10/15/90	4938



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS ± N/A DECIMALS .XX ± N/A .XXX ± ANGLES ±	CONTRACT NO.		
	APPROVALS	DRAWN Tom Baer	DATE 5/11/90
		CHECKED	5/18/90
MATERIAL			
FINISH			
NEXT ASSY / USED ON		REV A	
APPLICATION			

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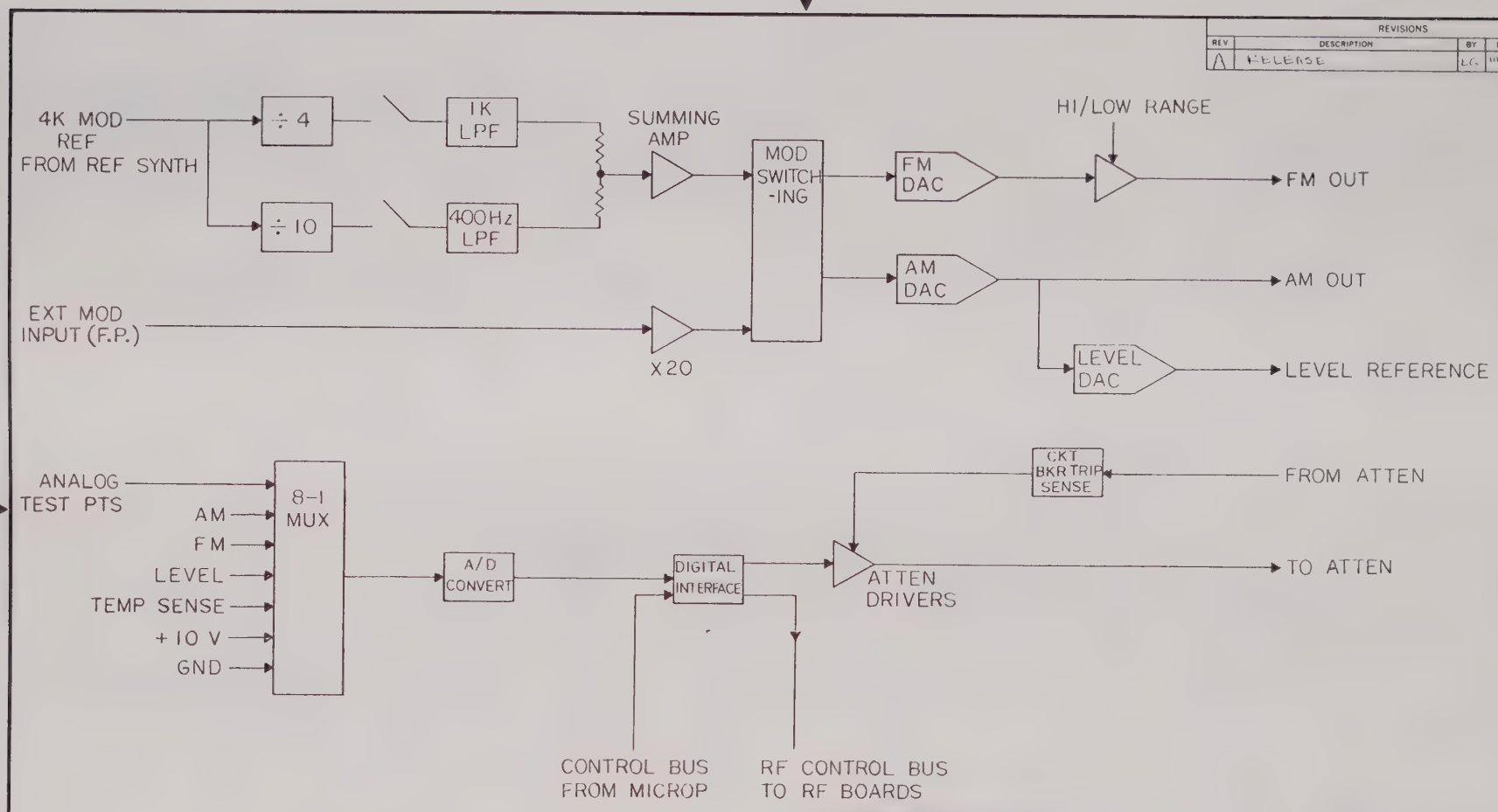
24XX LO/REF BLOCK DIAGRAM

SIZE	CODE IDENT NO.	DRAWING NO.
B	34280	0013-10-0040

SCALE NONE | DO NOT SCALE DRAWING | SHEET 1 OF 1



REVISIONS				
REV	DESCRIPTION	BY	DATE	P/N
A	RELEASE	EG	11/6/89	4938

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ARE:
FRACTIONS DECIMALS ANGLES
± N/A .XX ± N/A ± .XXX ± N/A ±

MATERIAL

FINISH

NEXT ASSY | USED ON

APPLICATION

CONTRACT NO.

APPROVALS	DATE
DRAWN Tim Pasa	5/14/90
CHECKED	

REV A

WAVETEK RF PRODUCTS, INC.

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24XX CONTROL BOARD
BLOCK DIAGRAM

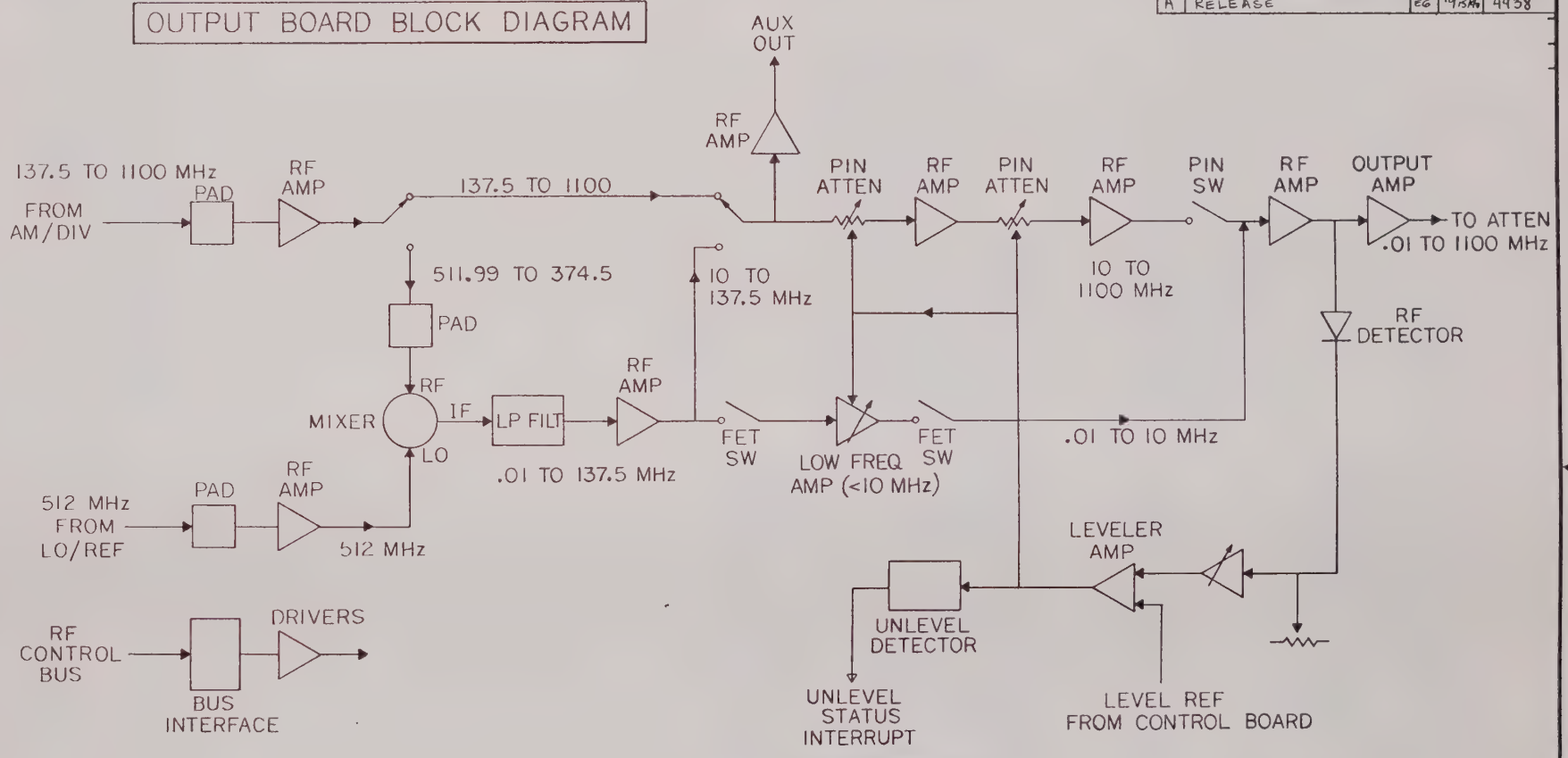
SIZE	CODE IDENT NO.	DRAWING NO.
B	34280	0013-10-0041

SCALE NONE | DO NOT SCALE DRAWING | SHEET 1 OF 1

TELEDYNE POST N24638

OUTPUT BOARD BLOCK DIAGRAM

REVISIONS				
REV	DESCRIPTION	BY	DATE	P/N
A	RELEASE	EG	1/15/90	4938



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS DECIMALS ANGLES ± N/A .XX ±N/A .XXX ±	CONTRACT NO.		WAVETEK RF PRODUCTS, INC.
	APPROVALS	DATE	*This document contains information proprietary to Wavetek. The information in this document is not to be used or duplicated in any manner without the prior approval in writing of Wavetek.*
	DRAWN Tim Baer	5/15/90	
MATERIAL	CHECKED EA	5/18/90	24XX OUTPUT BOARD BLOCK DIAGRAM
FINISH			SIZE B · CODE IDENT NO. 34280 · DRAWING NO. 0013-10-0042
NEXT ASSY / USED ON		REV A	SCALE NONE · DO NOT SCALE DRAWING · SHEET / OF /
APPLICATION			

TELEDYNE POST N24638

SECTION 8
TROUBLESHOOTING

8.1 INTRODUCTION

No troubleshooting guide can replace the knowledge and skills of experienced repair personnel. The purpose of this guide is to provide information to help the troubleshooter isolate the cause of an instrument failure, correct the problem, and return the unit to normal service as soon as possible. This guide also provides a general methodology for troubleshooting. Some failures are easily corrected. Others may require a thorough understanding of the circuit descriptions in Section 7 of this manual. Successful troubleshooters understand circuit operation within and between unit subassemblies. The troubleshooter should be familiar with the functional and detailed circuit descriptions and the schematics for this unit.

When the instrument is operating, but out of specifications (Section 1.2), performing the AutoCal® calibration procedure in Section 5.4 of the Manual may correct the problem.

8.1.1 INITIAL PREPARATION

Before attempting to troubleshoot the Model 2405/2410A, please read the theory of operation in Section 7 of this manual. Signal flow through the unit is traced in detail, with subassembly inputs and outputs clearly identified. The troubleshooter should be familiar with the relevant performance test procedures and maintenance procedures (especially the user diagnostics) detailed in Sections 4 and 5, respectively, of the manual.

8.1.2 METHODOLOGY

Troubleshooting is, in general, a systematic process of elimination. A thorough understanding of the circuit descriptions located in Section 7 of this manual will enable the trouble symptom to be associated with a particular circuit function. Once this has been accomplished, the problem can be further isolated using the reference schematics in Section 9. Voltage and resistance checks may then be used to locate the defective component.

8.1.3 FACTORY REPAIR

Wavetek maintains an on-site staff of highly skilled, experienced electronic technicians to provide assistance for those customers who lack the necessary test equipment or personnel to troubleshoot/repair the unit. Please obtain factory authorization before returning a unit for repair. If a unit is returned for repair, please include a detailed description of the problem encountered (to minimize turnaround time).

8.1.4 RECOMMENDED TEST EQUIPMENT

Recommended troubleshooting test equipment is listed in Table 8-1.

TABLE 8-1. RECOMMENDED TEST EQUIPMENT

INSTRUMENT	MODEL RECOMMENDED
Signal Generator	Wavetek Model 2500A or equivalent
Oscilloscope	Tektronix 2465 or equivalent, with matched X10 probes
Frequency Counter	Hewlett-Packard Model 5383A with external reference time base accuracy of ± 5 parts in 10^8, or equivalent
DVM	Fluke Model 8010A, or equivalent
Spectrum Analyzer	Tektronix 496, 492, or equivalent H-P 8559A, or equivalent
Spectrum Analyzer	Hewlett-Packard 8568, or equivalent
Measuring Receiver	H-P 8902A, with sensor module 11722A, or equivalent
Power Meter	Wavetek 8531, with Power Sensor 85312, or equivalent
Function Generator	Wavetek Model 20 or equivalent
Audio Analyzer	H-P 8903A, or equivalent
VSWR Bridge	Wiltron Model 60N50, or equivalent
Sweep Generator	Wavetek Model 2002A, or equivalent

8.2 PERSONNEL SAFETY CONSIDERATIONS

Maintain the standard safety precautions required when working around 100-240 VAC. Be aware that when the unit's cover is removed, there is 100 VAC at the back of the display board.

8.3 INSTRUMENT SAFETY CONSIDERATIONS

Static sensitive devices are used in this instrument. Use ESD precautions when handling a static sensitive device or a card on which a static sensitive device is mounted. These devices may not fail catastrophically if precautions are not taken, but the life of the device and its performance may be reduced and an early failure may result.

8.4 INITIAL INSPECTION

Instrument problems sometimes have simple, fairly obvious, solutions that are apparent upon visual inspections. Perform the following inspections before proceeding with extensive troubleshooting.

8.4.1 INPUT POWER

Verify the unit is plugged into an appropriate power source and is turned on. Verify the voltage selector (Section 2.4) is set properly. Verify the fuse in the AC Power Connector Module (Section 2.4) has not opened.

8.4.2 INCORRECT CONTROL SETTINGS

Verify a correct operating procedure has been used. Refer to Section 3 of the manual for a complete description of each front and rear panel control, display, and connector. Section 3 contains operating instructions for the unit.

8.4.3 VISUAL AND MECHANICAL CHECKS

Failures, whether they are continuous or intermittent, may be caused by any item listed in Table 8-2. The entire list may be checked out prior to further troubleshooting.

Note: Units are shipped from the factory in operating condition. Some items on this checklist can occur

because of improper handling during shipment and unpacking. Be aware that poor troubleshooting procedures can generate almost any of the items on the list.

TABLE 8-2.
VISUAL/MECHANICAL CHECKLIST

1. Loose RF Cables.
2. Loose cards.
3. Improperly mated connectors.
4. Burned or broken components.
5. Loose or missing screws.
6. RF cables to incorrect connectors.
7. Defective ribbon cables.
8. Solder joints on connectors or PC cards defective.
9. Incorrect power selection and fuse (see 2.4).
10. Defective contacts on cable connectors.
11. Defective wiring harness.
12. Broken wires.

8.5 GENERAL TROUBLESHOOTING NOTES

The user diagnostics and power up tests (Sections 5.3 and 5.5) and the error messages in sections 3.6.1 and 5.5 are powerful troubleshooting aids. The autodiagnostics error codes (section 5.3.1) are listed in Table 8-5 (see section 8.19). The error messages are described in detail in section 8.19 and 8.20. The key test is described in section 8.22.

8.6 REPAIR WORK CAUTIONS

8.6.1 CUSTOM COMPONENT REPLACEMENT

Reference schematic components that have a star (*) beside them are custom components. The value for the component, if shown, is its typical value and may or may not be its actual value. The actual values for custom components are determined at the factory during factory calibration. They are the values required to bring an individual unit into specification. Major repair of a subassembly may require a trial and error substitution for the custom components in related circuitry to recalibrate the unit.

8.6.2 ROUTINE REPAIR WORK CAUTIONS

Observe the standard precautions associated with any electronic instrumentation repair. For example:

- Make certain there are no solder shorts on any board.

- Check the pin 1 location of any IC that is removed and reinserted or replaced; make certain that the IC is inserted correctly.

- Make certain electrolytic capacitors are installed properly.

8.7 POWER SUPPLY

The Power Supply circuitry is described in detail in Section 7.14. A power supply problem may cause many seemingly unrelated symptoms. The power supply should be checked when a symptom(s) does not clearly indicate a specific trouble area.

8.7.1 UNIT TOTALLY INOPERATIVE

If the unit is totally inoperable, check the power supply. If there is no output or a low output, check the line fuse and verify that the voltage selector switch is in the proper position.

8.7.2 VOLTAGES

If the +18 V is inaccurate, check Q1301, IC1301, IC1300, and CR1300.

If the -18 V is not present, verify the +18 V supply (the -18 V supply will not come up without the +18 V supply). If the +18 V supply is correct, check Q1302, Q1303, IC1301, and CR1300.

If the +8 V is inaccurate, check IC1302, CR1305, and CR1306.

If the fan B^+ is absent, check Q1304, CR1307, CR1305, and CR1306.

If the power supply voltages are in range, verify the microprocessor board is functional (See Sections 7.3 and 8.9).

8.7.3 GROUNDS

Sense ground (J1302, pin 7) and chassis ground (J1302, pins 8/9) must be connected together for proper output voltage.

8.8 ON-BOARD REGULATORS

A voitage level problem on the individual boards in this unit may be the result of a defective regulator or a defective electrolytic capacitor. Voltmeter tests with the power supply turned on will normally reveal any such problem.

8.9 MICROPROCESSOR BOARD

Microprocessor Board circuitry is described in Section 7.3. (See section 8.24 for GPIB troubleshooting).
Verify the power supply voltages before working on the

microprocessor board. The microprocessor board is complicated. Carefully read Section 7.3 before troubleshooting this board.

Microprocessor board circuitry controls much of the unit's operation. Proper operation of the board is indicated by the front panel displays during the automatic power up test (described in Section 5.5). Erratic or nonsense operation may result if microprocessor circuitry is bad, or the unit may be totally inoperable.

8.9.1 BASIC SYSTEM TIMING/CONTROL SIGNALS AND LINES

Basic system timing is derived from the 3.579545 MHz crystals (X101, X102) on the microprocessor board. The microprocessors (IC101, Figure 9-1 and IC121, Figure 9-2)) provide the 1 MHz system clocks and the clock enables used to generate the various clocks that provide timing for control functions.

There are several control signals and address and bus lines that are required for proper system operation. Usually it is only necessary to verify these signals and lines are switching.

8.9.2 POWERUP DISPLAY "FAIL" INDICATORS

If the display indicates "Dual port RAM test: FAIL" on powerup:

Verify the control μP ROM (IC103) is installed correctly (no bent lead).

Check the Enable clock (IC101 pin 40) for a 1 MHz clock. If bad, either IC101 or its associated oscillator circuit is bad.

Check the INTCOM low signal (IC112 pin 44) to verify the interrupt request to the control μΠ. If that is not the problem, there are two possibilities. Verify the decode selection CSO line (pin 25) pulses low. A decode selection CSO line that does not pulse low indicates a problem with IC128. Verify that IC101 pin 5 also pulses low. If IC101 pin 5 does not pulse low, IC134 or IC135 is probably the problem.

If the display shows ""Calibration table: FAIL" on powerup:

A nonvolatile memory (IC104) failure may have occurred. The failure may be caused by inserting a new software version or a battery failure of IC204. Rerun the calibration process using the status menu selection.

If the display indicates ""Instrument setting: FAIL" on powerup:

A nonvolatile memory (IC104) failure may have occurred. The failure may be caused by inserting a new software version or a battery failure of IC204. The default settings will be reloaded automatically.

8.9.3 NO RF RESPONSE

If the front panel display and keyboard are operational, but there is no RF response:

Check the decode select to IC106 (pin 25) for TTL pulses. If no pulses are present, verify that IC108 and IC110 decoder logic are good. If IC108 and IC110 are good, check IC106 pins 24, 26, 27, 28 for TTL pulses. If pulses are present, check IC106 and its pull up resistors.

8.9.4 KEYBOARD NOT FUNCTIONAL

If the front panel display looks right, but the keyboard does not function:

Check IC127 pins 3-10 for logic level low. If these pins are low, verify IC127 and its corresponding decode logic (IC128) are functioning. Also verify that pins 11-20 in all the ICs are pulled high. If all pins are not high, one or more keys may be stuck.

When a key is pressed, verify that one of the lines on pins 11-19 of IC127 goes low. If this does not happen, suspect a keyboard problem. With each keypress, line CB1 (IC127, pin 20) should pulse high. If not, suspect IC129. With each keypress, pin 41 of IC127 should pulse low. Pin 5 of IC121 also should pulse low. If either does not happen, suspect IC127 or ICs 134-136.

8.10 CONTROL BOARD

The Control Board is described in detail in section 7.4 of this manual.

8.10.1 MODULATION

Possible modulation problems fall into several categories. Problem areas and circuitry to check for each are:

PROBLEM	CHECK
Modulation source switching	IC249, IC233, IC223, and IC230
1 kHz source	IC235 and IC236
400 Hz source	IC234 and IC236
Ext Mod	IC239

PROBLEM	CHECK
FM	IC242, IC243, IC237, IC238, IC248, and IC249
AM	IC244, IC253, IC237, IC238, IC248, and IC249
Level	IC245, IC246, IC253, and IC248

8.10.2 REVERSE POWER PROTECTION

For problems with the RF reverse power protection (circuit breaker) circuitry, check IC216, Q201, Q202, and Q203.

8.10.3 ATTENUATOR CONTROL

For attenuator control problems, check IC201 and IC202.

8.10.4 RF CONTROL

If RF control circuitry does not work properly, check IC204, IC205, IC211, IC203, IC206, and IC207.

8.10.5 FREQUENCY CALIBRATION

Frequency calibration problems may be due to a bad peak detector. Check IC217-IC229.

8.11 DDS BOARD

The DDS board is described in detail in section 7.5 of this manual.

8.11.1 OUTPUT LEVEL

If no output is being generated at the DDS output connector, J100 check the following circuits for proper operation:

DAC IC132, output amplifier IC133 and it's associated components, the output filter C149-C153, C169-C171, L100, L101 and inverter IC135.

Check also to be sure the RUN/CLR signal at pin 17A of P101 is not shorted to ground and that the 10 MHz reference is present at pin 27A of P101.

If the output level is low or high, check IC132, IC133 and the output filter.

8.11.2 OUTPUT SPURS/HARMONICS

If the output has high spur and or high harmonic levels but is still on frequency, sine proms ICs 127 and 128 data could be corrupted. Also check DAC IC132, output amplifier IC133, and output filter for proper operation.

8.11.3 OUTPUT FREQUENCY

If the output frequency is not correct:

Verify that the 10 MHz reference frequency is correct.

A failure in one of the BCD adder ICs may result in a frequency error associated only with one digit of resolution. The following chart indicates the adder associated with each digit of resolution.

IC120	.00001	kHz
IC116	.0001	kHz
IC119	.001	kHz
IC115	.01	kHz
IC118	.1	kHz
IC114	1.	kHz
IC117	10.	kHz
IC113	100.	kHz
IC140	1000.	kHz

8.12 REFERENCE SYNTHESIZER BOARD

The Reference synthesizer is described in detail in section 7.6 of this manual.

8.12.1 OUTPUT LEVEL

If the Ref synth output level is low or missing, check the output level of the VCO (approx = 1vp-p) at pin 5 of IC1516 and the input and output levels of IC1517 (should be TTL levels). Check also the input and output levels of voltage regulators ICs 1505, 1506 and 1520.

8.12.2 OUTPUT FREQUENCY

If the Ref synth output frequency is incorrect, one of two conditions may exist:

1) The PLL is unlocked

2) The PLL is locked but at the wrong frequency

When the PLL is unlocked, the PLL correction voltage at the output of IC1512 pin 1 will be at its maximum or minimum level and the Int 5 signal at P1501 pin 26 should be at +5 vdc. To localize the problem in an unlocked PLL first determine if the output frequency is too high or too low, then check the polarity of the PLL correction voltage. If the output frequency is too high and the correction voltage is at its maximum positive level this indicates that the loop is trying to tune the VCO

to a lower frequency. This condition may indicate a problem in the tuning range of the VCO or an incorrect division ratio in the divide by 32 (IC1516). If the output frequency is too high and the correction voltage is at its maximum negative level, this indicates that the loop is driving the VCO off frequency. Several things could cause this condition including:

1) Improper programming of the Divide by N (IC1507-1509)
2) 1 MHz reference missing or off frequency
3) Incorrect division ratio in the divide by 32 (IC1516)
4) Phase detector or loop filter failure (ICs 1518 and 1512 and their associated components)
5) Failure in the zero crossing detector (IC1519), mixer (MX1501), or buffer amp (Q1504)

If the loop is locked but at the wrong output frequency, a problem may exist in the programming of the Divide by N (ICs 1507-1509), the Digital interface (ICs 1501-1504) or the frequency of the DDS input at J1501. (The frequency of the DDS input should be 1.0000000 Mhz at any FP frequency setting where all the digits to the right of the decimal point are zero.

8.12.3 MODULATION REFERENCE

If the instruments internal 1 kHz and 400 Hz modulation sources are not functional, one possible cause could be a failure of the 4 kHz modulation reference from the reference synthesizer. Check the 1 MHz reference input at pin 5 of P1501. This signal is divided by 25 by IC1521 and then by 10 by IC1522 for a total division of 250. The last stage of IC1522 is a divide by 2 so the 4 kHz output at pin 22 of P1501 should have a 50% duty cycle.

8.13 RF SYNTHESIZER BOARD

The RF Synthesizer Board is described in detail in section 7.7 of this manual.

8.13.1 RF OUTPUT LEVEL

For no RF output (at J501) or too low an output, check the amplifier circuitry (IC420 and associated components) or the VCO (IC500 and associated components).

8.13.2 RF OUTPUT HARMONICS/SPURS

If output harmonics are too high, check VCO (IC500 and associated components).

If output spurs at 100 kHz are too high, check the 100 kHz trap (L404, C476). Then check for a loop pole problem (C450, C435, C427, C431). 8.13.3 FM
For no FM or FM too low, check FM control (IC405, IC413) and FM path (IC413, R424, R433, IC417, and associated components) circuitry.

For FM too high, check FM attenuator (R424, R433) and FM buffer (IC417 and its associated components.

8.13.4 FALSE UNLOCK OR TPX INDICATION

If a false UNLOCK indication occurs, the most likely cause is IC418 or its associated circuitry.

If a false TPX indication occurs, check TPX control circuitry (IC405, IC419) and TPX amplifier/buffer circuitry (IC418 and its associated components).

8.13.5 RF SYNTHESIZER UNLOCKED

If the synthesizer becomes unlocked, there may be a problem with:

The VCO circuitry (IC500 and its associated circuitry.

The buffer/divide-by-10 prescaler circuitry (IC421, IC422, IC416, IC415, and associated circuitry.

The divide-by-5/6 prescaler circuitry (IC410 and its associated components).

The PLL (IC407, IC408, IC409, and associated components).

The loop filter (IC411, IC413, IC414, IC417, and associated circuitry).

The coarse tuning circuitry (IC414, IC418, and associated components).

The control/data transfer circuitry (IC400, IC404, IC405).

Also check the ref synth input at J502 for proper frequency and level.

8.14 REFERENCE/LO BOARD

The Reference and LO Board is described in detail in section 7.8 of this manual.

8.14.1 LO OUTPUT

If there is no LO output at J602, check:
For a disabled LO (IC607, IC694, Q605, Q604, and associated circuitry).

For a VCO not oscillating (Q603 and associated circuitry).

For an amplifier problem (IC605 and associated circuitry). For too low an output at J602, check the amplifier (IC605 and associated circuitry).

8.14.2 LO UNLOCKED

If the LO becomes unlocked, check:

The VCO circuitry (CR601, C652, C653, C654, Q603).

The prescaler circuitry (IC602 and associated circuitry).

The PLL (IC601 and its associated circuitry).

The loop filter (IC608, IC603, IC607, and their associated circuitry).

A reference problem (IC604, Y601, Q606, CR606, IC613, IC612, and their associated components).

If the LO is not locking on EXT REF, check IC604, IC612, CR607, and their associated circuitry.

8.14.3 FALSE LO UNLOCK

For a false UNLOCK indication, check IC608, Q601, and associated circuitry.

8.14.4 INT REF OUTPUT

If there is no INT REF output or the output level is too low, check IC614 and its associated circuitry.

8.15 DOUBLER BOARD

The Doubler Board is described in detail in section 7.9.

8.15.1 UNLEVELED OUTPUT

A doubler board failure will most likely cause an unleveled output across the entire output frequency range or just at specific frequency bands.

To determine if the doubler board is functioning properly, measure the output level of the synthesizer and doubler boards at a frequency where a failure occurs. Both should be 0 ± 3 dBm.

If the output of the doubler is unleveled, the output of IC1511 (pin 7) should go to approximately +13 VDC.

8.15.2 LOW DOUBLER OUTPUT

If the output of the doubler is low across all or most of the output frequency range, check the input coax cable. Check the +5, +15, and -15 V voltages at regulators IC1508, IC1506, and IC1507. Check for damaged chip components associated with amplifiers IC1500, IC1501, IC1512, and IC1502. Check the amplifiers' output bias voltages for approximately +5 VDC.

If the doubler fails only at certain frequency bands, check the control signals associated with those frequency bands as listed in the following chart:

FREQ RANGE (MHz)	CONTROL SIGNALS F	D1	D2	D3
275-550	X	-	-	-
550-693	-	X	-	-
693-873	-	-	X	-
873-1100	-	-	-	X

where X = approx +15 V
- = approx -15 V

For any control signals not at proper levels, check their associated buffer transistors (Q1500-1507) and IC1509. Check the switched filter bank PC assembly for any damaged components.

If a failure occurs above 550 MHz only and the control signals are at proper levels, check the frequency doubler G1500 and associated PIN diode switches (CR1500-1503).

8.16 AM/DIVIDER BOARD

The AM/Divider Board circuitry is described in Section 7.10. Troubleshooting the circuitry involved is a straight forward procedure.

8.16.1 FREQUENCY CONVERSION CIRCUITRY

Check the input and output of each band in a frequency conversion network to isolate a problem. Be aware of common problems. For example, if neither the 195-275 MHz nor the 137.5-195 MHz band is operational, the problem is common to both bands (and could be that voltage regulator IC701 or frequency divider IC700 is malfunctioning).

When a failed network has been isolated, the usual problem is a failed component.

Band switching diodes control the signal paths through the frequency conversion circuits. If the correct diodes are not turned on, the output signal will not be correct. The band switch/diode relationships are shown in Table 8-3 on next page.

TABLE 8-3.
BANDSWITCH/DIODE RELATIONSHIPS

Band	Diodes Turned On
1 (550-1100 MHz)	CR700,728,702
2 (390-550 MHz)	CR701,727,703
3 (275-390 MHz)	CR704,705,715,706
4 (195-275 MHz)	CR704,707,711,712,708
5 (137.5-195 MHz)	CR704,707,713,714,708

8.16.2 LEVEL CONTROL CIRCUITRY

Level control is performed by PIN diode pairs CR729/CR730 and CR731/CR732, which are driven through transistors Q700 and Q703 by the output at pin 1 of IC705B.

8.17 OUTPUT BOARD

The Output Board is described in detail in section 7.11 of this manual. Troubleshooting the circuitry involved is a straight forward procedure.

8.17.1 FREQUENCY CONVERSION CIRCUITRY

There are three frequency conversion paths for signal flow. Check the input and output of each path to isolate a problem. Be aware of common problems. For example, if Amplifier IC803 opens, there will be no signal at the straight through path or heterodyne 1 path.

When an inoperable path is isolated, the usual problem is a failed component.

The signal paths are controlled by switching diodes. If the correct diodes are not turned on, the output signal will not be correct. Table 8-4 shows the switch/diode relationships.

Gain control for the THRU path and the HET1 path is performed by PIN diode pairs CR811/CR812 and CR815/CR816, which are driven through transistor Q808 by the output at pin 1 of Comparator IC808. HET2 path gain control is performed by Dual Gate FET Q804, which is driven through transistor Q808 by the output at pin 1 of Comparator IC808.

TABLE 8-4.
PATH/SWITCH RELATIONSHIPS

Path	Switches Turned On
THRU	CR800-804, CR821
HET1	CR800, CR810, CR821
HET2	CR800, CR810, Q800, Q802

8.17.2 OUTPUT AMPLIFIERS

IC812 is the output amplifier.

8.17.3 CONTROL LOGIC

The control logic circuitry is detailed in Section 7.11.7.

8.18 DISPLAY/KEYBOARD

The Display/Keyboard is described in detail in section 7.13. Verify a keyboard problem is not strictly a physical one (sticking key, damaged area, etc.). The Keyboard and Display interface through the Microprocessor Board. Look at Figure 9-2 for the following hints.

If the front panel display and keyboard are operational, with no RF response:

Check the decode select to IC106 (pin 25) for TTL pulses. If no pulses are present, verify that IC108 and IC110 decoder logic are good. If IC108 and IC110 are good, check IC106 pins 24, 26, 27, 28 for TTL pulses. If pulses are present, check IC106 and its pullup resistors.

If the front panel display is working, but the keyboard does not function:

Check IC127 pins 3-10 for logic level low. If these pins are low, verify IC127 and its corresponding decode logic (IC128) are working properly. Also verify that pins 11-20 in all the ICs are pulled high. If all pins are not high, one or more keys may be stuck.

When a key is pressed, verify that one of the lines on pins 11-19 of IC127 goes low. If this does not happen, suspect a problem with the keyboard. When a key is pressed, line CB1 (IC127, pin 20) should pulse high. If not, suspect IC129. When a key is pressed, pin 41 of IC127 should pulse low. Pin 5 of IC121 also should pulse low. If either does not happen, suspect IC127 opr ICs 134-136.

8.19 AUTOMATED DIAGNOSTIC ERROR CODES

Pressing a "1" or the status key from the diagnostics select menu will start the diagnostic tests shown in Table 5-1. If a failure results, automatic testing will halt. The display will look like:

DIAGNOSTIC ACTIVE: (diagnostic name)
FAIL XXXX 1:CONT 2:REPEAT +:Exit

A code "XXXX" for the specific cause of the test failure will be indicated on the second line of the display.

Detailed information related to failure codes is listed in Table 8-5. A failure of the non-volatile RAM test might produce the following display:

DIAGNOSTIC ACTIVE:NON-VOLATILE RAM
FAIL 0000 1:CONT 2:REPEAT +:Exit

The "0000" (see Table 8-5) indicates the control microprocessor is bad.

8.20 INSTRUMENT ERROR MESSAGES

The error messages described in section 3.6.1 may have the following causes.

8.20.1 MFREQ

The mod frequency reference accuracy (MFREQ) test is performed repetitively when the unit is setting idle and the internal mod source is enabled. The mod source is enabled when Int AM is on, or Int FM is on and not set to 0 kHz. The test consists of monitoring the TTLMOD testpoint on the control card and verifying that the signal at this point is the current mod rate selection frequency (400 or 1000 Hz). The test measures the amount of time the line is at logic 0 and at logic 1 and indicates a failure if either of these is out of tolerance. The time duration for the 0 state and the 1 state are the same, and are given as follows:

400 Hz rate = 1250 ± 500 msec
1000 Hz rate = 500 ± 250 msec

This test also is performed in the autodiagnostics test called 400 Hz FEEDBACK. In the diagnostics test, however, the mod reference frequency is checked whether internal mod is selected or not.

Possible causes for this error are:

external reference is selected instead of internal reference and no external reference signal is applied.

IC230 is not programmed properly or is not dividing properly. This must be the case if the 4 kHz reference input and the 400 Hz and 1 kHz inputs to IC233 are correct and functioning properly.

8.20.2 TRIP

A ""TRIP" message on the display indicates a tripped circuit breaker. The indication is from the feedback line from the control card to the microprocessor card and corresponds to PA0 (pin3) of IC105 on the microprocessor card. The status of the feedback inputs to IC105 also can be observed in the DIAGNOSTICS DEBUG LATCH mode by selecting the microprocessor card (card select 1) and the Interrupt latch (latch select 3). This line will correspond to bit 0 being high, which is a hex value $01. Note that more than 1 bit may be set when reading this latch, so a value of $09 or $05 , etc., also indicates this line is high.

The circuit breaker will trip if an input signal is applied to the RF input of the instrument. This signal level is monitored by the DETOUT line from the attenuator to the control card. A large enough signal will cause the output of IC216 pin 1 to go negative, cutting off Q203, forcing the TRIP line high. With RF OFF, the TRIP line should always be 0. When the RF is toggled from on to off to on again, the circuit breaker should be reset if it was tripped.

8.20.3 UNLOCK1

The "UNLOCK1" message on the display indicates the RF synthesizer loop is unlocked. The indication is from the feedback line from the RF synthesizer card to the microprocessor card and corresponds to PA3 (pin 6) of IC105 on the microprocessor card. The status of this line also can be observed in the DIAGNOSTIC DEBUG LATCH mode (see TRIP error). The value for this bit is $08.

TABLE 8-5 AUTOMATED DIAGNOSTIC ERROR CODES

DIAGNOSTIC	CODE	PROBLEM
Ctrl Microprocessor	0000	Control Microprocessor Bad
	0001	Control Microprocessor Timer failure
		Either error will occur if the control microprocessor is bad. Error 0000 will occur if the control microprocessor PROM, EP320 decoder, or data/address bus is bad.
Comm Microprocessor	0000	Communication Microprocessor Timer failure or Communication Microprocessor bad

TABLE 8-5 AUTOMATED DIAGNOSTIC ERROR CODES (CON'T)

DIAGNOSTIC	CODE	PROBLEM
Non-volatile RAM	0000	Control Microprocessor Bad
	0001	Non-bankswitched RAM failure
	0002	Page 1 RAM failure
	0003	Page 2 RAM failure
	0004	Page 3 RAM failure
	0005	Page switch error (also occurs if 8k installed with extended stored settings option)
		Errors 0000-0005 can occur if the NVRAM device is bad. Errors 0002-0005 can occur if RAM page switch lines are bad. Error 0005 can occur if 8k NVRAM installed with extended stored settings option (requires 32k NVRAM)
Dual Port RAM	0000	Control Microprocessor Bad
	0001	Comm R/W failure
	0002	Comm W/ Ctrl R failure
	0003	Ctrl R/W failure
	0004	Ctrl W/ Comm R failure
	0005	Timeout error
		Errors 0001-0005 can occur if the 1DT7130 is bad. Error 0005 will occur if the control microprocessor is dead (see Ctrl Microprocessor Test error 0000)
Static Ram	0001	Communication Microprocessor RAM failure
		Communication Microprocessor RAM or EP320 address decoder bad
Control EPROM	0000	Ctrl Microprocessor Bad
	0001	Ctrl Microprocessor EPROM checksum failure
		May be caused by bad data in PROM device
Communications EPROM	0001	Comm Microprocessor EPROM checksum failure
		May be caused by bad data in PROM device
RF Data/Address Bus	0000	Control Microprocessor Bad
	0001	R/W of data $00 failed
	0002	R/W of data $FF failed
	0003	R/W of data $55 failed
	0004	R/W of data $AA failed
	001X	R/W of walking 1's data failed (X indicates bit position of digit)
		Caused by failure of the data input/output latches on the control card
Card ID Code	0000	Ctrl Microprocessor Bad
	0XXX	Bit position of card ID code failures are set as follows:
	001	bit 0: card 0, DDS ($31)
	002	bit 1: card 1, (not used)
	004	bit 2: card 2, Control ($00)
	008	bit 3: card 3, Option ($28)
	010	bit 4: card 4, RF Synthesizer ($09)
	020	bit 5: card 5, Doubler ($30)

TABLE 8-5 AUTOMATED DIAGNOSTIC ERROR CODES (CON'T)

DIAGNOSTIC	CODE	PROBLEM	
	040	bit 6: card 6, AM/Divider	($18)
	080	bit 7: card 7, Output Amp	($20)
	100	bit 8: card 8, LO	($10)
	200	bit 9: card 9, Reference Synthesizer	($68)
		Any of these indicates that either the indicated card is missing, or the ID code latch of that card is bad or miswired, or the RF data/address bus drivers on the control card are bad.	
ADC/DAC	0000	Ctrl Microprocessor Bad	
	00XX	Bit position of failed tests are set as follows:	
	01	bit 0: 0 v ref (+ peak)	
	02	bit 1: +10 v ref (+ peak)	
	04	bit 2: level DAC min (+ peak) max (+/- peak)	
	08	bit 3: AM DAC min (+ peak) max (+/- peak)	
	10	bit 4: FM Dac min hirange (+ peak) max hirange (+/- peak)	
	20	bit 5: max lorange (+/- peak)	
		All of the errors can be caused by a bad A/D (composed of the DAC, counters, mux, and "glue logic"), ± 15 V supply failure, or no 1 MHz reference from the LO board. The 10 V ref error also can be caused by a bad 10 V ref. The AM and FM DACs errors can be caused by improperly set mod reference levels for the corresponding DACs. If the FM DAC fails either the hirange or the lorange, but not both, the cause might be the FMRG line that selects the multiplication factor.	
LO Unlock	0000	Ctrl Microprocessor Bad	
	0001	Unlock at 100 MHz	
	0002	No unlock when LO division ratio changed	
RF Synthesizer Unlock	0000	Ctrl Microprocessor Bad	
	0001	Unlock at 550 MHz	
	0002	No unlock when LO VCO selected	
Carrier Unlevel	0000	Ctrl Microprocessor Bad	
	0001	Unleveled at 275 MHz, +13 dBm	
	0002	Output amp not unleveled when all of the RF paths are deselected	
400 Hz Feedback	0000	Ctrl Microprocessor Bad	
	0001	TTLMOD never goes lo (0)	
	0002	TTLMOD never goes hi (1)	
	0003	TTLMOD timeout: stays hi > 3 msec	
	0004	TTLMOD timeout: stays lo > 3 msec	
	0005	TTLMOD hi duration < min allowed	
	0006	TTLMOD hi duration > max allowed	
	0007	TTLMOD lo duration < min allowed	
	0008	TTLMOD lo duration > max allowed	
		Note: min = 382 µsec for 1 kHz : 1000 µsec for 400 Hz max = 628 µsec for 1 kHz : 1490 µsec for 400 Hz	

The autotest selection of the diagnostics mode performs a check on this line called SYNTHESIZER UNLOCK. This test consists of setting the frequency of the unit to 550 MHz (Mod off) and checking this line for a locked condition (0). The LO VCO is then selected, and this line is tested for an unlocked condition (1). If either of these tests fail, the SYNTHESIZER UNLOCK test fails.

If this UNLOCK message occurs, perform the calibration described in Section 5.4 of this manual. (If this procedure does not erase the UNLOCK indicator, the unit has a problem that will require troubleshooting. Wavetek recommends returning the unit to the factory for repair, after factory authorization, unless the customer has highly qualified maintenance personnel that are experienced at RF repair work.)

8.20.4 UNLOCK2

The "UNLOCK2" message on the display indicates the LO (Local Oscillator) loop is unlocked. The indication is from the feedback line from the LO card to the microprocessor card and corresponds to PA2 (pin 5) of IC105 on the microprocessor card. The status of this line also can be observed in the DIAGNOSTIC DEBUG LATCH mode (see TRIP error). The value for this bit is $04.

The autotest selection of the diagostics mode performs a check on this line called LO UNLOCK. This test consists of setting the frequency of the unit to 100 MHz (Mod off) and checking this line for a locked condition (0). The phase locked loop divide ratio of the LO is then changed, and this line is tested for an unlocked condition (1). If either of these tests fail, the LO UNLOCK test fails.

If this UNLOCK message occurs, perform the calibration described in Section 5.4 of this manual. (If this procedure does not erase the UNLOCK indicator, the unit has a problem that will require troubleshooting. Wavetek recommends returning the unit to the factory for repair, after factory authorization, unless the customer has highly qualified maintenance personnel that are experienced at RF repair work.)

8.20.5 UNLOCK 3

The ""UNLOCK 3" message on the display indicates the REFERENCE SYNTHESIZER loop is unlocked. The indication is from the feedback line from the reference synthesizer card to the microprocessor card and corresponds to PA5 (pin 8) of IC105 on the microprocessor card.

If this error occurs, verify that all inputs to the reference synthesizer (DDS input, 1 MHz reference, power supplies, data and address bus) are at nominal levels and frequencies. If no problem is found with the inputs, troubleshooting of the reference synthesizer card is necessary. Wavetek recommends returning the unit to the factory for repair, after factory authorization, unless the customer has highly qualified maintenance personnel that are experienced at RF repair work.

8.20.6 UNLEV

The UNLEV (Unlevel) message indicates the output amplifier is unleveled. The indication is from the feedback line from the output amplifier card to the microprocessor card and corresponds to PA4 (pin 7) of IC105 on the microprocessor card. The status of this line also can be observed in the DIAGNOSTIC DEBUG LATCH mode (see TRIP error). The value for this bit is $10.

The autotest selection of the diagostics mode performs a check on this line called CARRIER UNLEVEL. This test consists of setting the frequency of the unit to 275 MHz and the level to +13 dBm (Mod off) and checking this line to verify the unit is leveled (0). All the PIN diodes on the output card are deselected, and this line is retested to verify the unit is unleveled (1). If either of these tests fail, the CARRIER UNLEVEL test fails.

If an UNLEV message occurs, perform the calibration described in Section 5.4 of this manual. (If this procedure does not erase the UNLEV message, the unit has a problem that will require troubleshooting. Wavetek recommends returning the unit to the factory for repair, after factory authorization, unless the customer has highly qualified maintenance personnel that are experienced at RF repair work.)

8.20.7 CONTROL UP COMMUNICATION FAILURE

The CONTROL uP COMMUNICATION FAILURE message indicates that communication between the two microprocessors has failed. Failure of the communication link, the dual-port RAM (IC112), will generate this message. Failure of either the control or communication microprocessor or any of their associated memory and decoding also will generate this message.

To verify that the control microprocessor is operating, check LED104, the pad connected to pin 11 of IC105. This line should be toggling at a rate between 250 µsec and 2 µsec. This indicates the speed of execution of the background processes. If the line is not toggling, or is at a rate much slower than this, the control microprocessor is not functioning. This could be due to the microprocessor losing its clock (check pin 40 for approximately 1 MHz out), or not accessing memory correctly (check IC102, IC103, and IC104).

8.21 FREQUENCY CALIBRATION ERROR MESSAGES

Frequency calibration errors (described in section 5.4.1) typically are due to hardware problems. Wavetek recommends returning the unit to the factory for troubleshooting and repair. Errors are shown in the upper right-hand corner of the display, preceded by the message FAIL. The lower right-hand corner of the display will show PRESS STATUS TO EXIT. An A/D error message will look like:

FREQUENCY 275 MHz FAIL: A/D ERROR
CALIBRATION +:EXIT

Calibration error messages may have the following causes.

8.21.1 A/D ERROR

The A/D ERROR message indicates an A/D reference voltage reading error. It occurs when the frequency calibration process is first begun, before any calibration points have been generated. It shows the A/D is not reading valid ground (0 v) and +10.0 v references. The valid readings are:

0.0 V = $FF9C to $FFF and $0000 to $0064

10.0 V = $079C to $0800

8.21.2 COARSE LOW ERROR

This error can occur at any frequency calibration point, because the coarse DAC attempts to adjust the synthesizer error testpoint to 0 v at each point. If the coarse tune DAC can not be decreased as much as it needs to be, the COARSE LOW error will occur. The COARSE LOW error occurs when the coarse tune DAC value equals $00 and the error voltage is not 0 v. The error results if the error voltage is positive ($0002 < A/D value < = $0800), even if the coarse DAC has decreased to $00.

8.21.3 COARSE HI (HIGH) ERROR

This error can occur at any frequency calibration point, because the coarse DAC adjusts the synthesizer error testpoint to 0 v at each point. The COARSE HI error occurs if the coarse tune DAC can not be increased as much as it needs to be. The COARSE HI error occurs if the coarse tune DAC value equals $FF and the error voltage is not 0v. The error occurs if the error voltage is negative ($F800 <= A/D value < $FFFE), even if the coarse DAC has increased to $FF.

8.21.4 FM DAC LOW ERROR

The FM DAC LOW error can occur at any frequency calibration point. After the coarse DAC has been adjusted for an error voltage near 0 v (at each calibration point), the FM is changed from the 0 kHz adjustment value to 1 MHz, and the unit frequency is increased by 1 MHz. The FM DAC value is adjusted by successive approximation from the most significant bit to the least significant bit (12 steps) to get the A/D value to equal the value read when the coarse tune DAC was adjusted. The FM DAC is initialized to $FFF (maximum). If the error voltage read is greater than the value when the coarse DAV was adjusted, the next significant bit of the FM DAC is set to 0, otherwise it is left at 1. After all 12 bits have been adjusted, the resulting FM DAC value is the value needed to produce a 1 MHz FM deviation, and is saved as the FM calibration factor for the current unit frequency. If the FM DAC value is $000, and the error voltage still is too high, the error is flagged to indicate the error voltage read with FM applied is greater than the desired 1 MHz offset value. In other words, the FM DAC value is minimum ($000) and the error voltage can not be adjusted lower. An incorrectly adjusted mod reference can cause this error.

8.21.5 FM DAC HI (HIGH) ERROR

The FM DAC HI error is generated in the same manner as the FM DAC LOW error described in section 8.20.4 except the error occurs when the resulting FM DAC value is $FFF and the error voltage is still too low. The error is flagged to indicate the error voltage read with FM applied is less than the desired 1 MHz offset value. In other words, the FM DAC value is maximum ($FFF) and the error voltage can not be adjusted higher. An incorrectly adjusted mod reference or a problem with the FM range select bit (FMRG on the control card) can cause this error.

8.21.6 FM UNSTB (UNSTABLE) ERROR

The FM UNSTB error indicates the synthesizer error testpoint A/D value read during either the coarse tune or the FM DAC adjustments was not stable. This means that the A/D value was read 10 times and no two successive readings differed by 1 or less. This indicates either the A/D itself is not stable due to poor grounding, etc., or the synthesizer error voltage does not remain stable between successive readings.

8.22 KEY TEST

The key test checks for stuck keys and for miswired and no-contact keys. The key test screen is:

KEY TEST: PRESS TO DISPLAY KEY +: Exit
xxxxxx

A stuck key will be shown in the "xxxxxx" location on the display when no key is pressed. If more than one key is stuck, the key label shown is the key corresponding to the lowest row and lowest column of all of the keys that are stuck. Table 8-6 lists key labels and key locations (row and column). For example, if the "5" key (row 3 column 3) and the "FREQ" key (row 4 column 0) are both stuck, the key label displayed will be the key label for row 3 column 0, which is the "7"

Pressing any key will produce the mnemonic associated with the key in the "xxxxxx" display location. For example, pressing the "Mod Off" key will produce the following display:

KEY TEST: PRESS TO DISPLAY KEY +:Exit
MOD OFF

If a key makes no contact, pressing it will not display a label.

Remember to check the "+" key and the "STATUS" key last because these will recall the diagnostics menu.

A wiring problem on the keyboard, motherboard, or microprocessor card, or in the cable from the motherboard to the front panel card may generate a stuck or no-contact key indication or result in wrong labels displayed for selected keys.

By comparing the keys pressed to the labels displayed, faulty row or column logic may be detected. For example, if all of the keys in row 5 are displayed as the corresponding keys in row 4, these two rows may be shorted together, or the row 4 data line may be shorted to ground.

8.23 DACs TEST

Section 5.3.4 contains troubleshooting information associated with the DACs test diagnostics. The A/D testpoints shown in Table 5-2 require specific cards to be operational. If one of the cards required for a selected testpoint is missing from the system, its associated testpoints are not available. The Control card is required for all DACs diagnostics. Table 8-7 lists the testpoints and other (besides the Control card) required cards. See next page.

TABLE 8-6 KEY LABELS/LOCATIONS

KEY LABEL	LOCATION Row	Column
INT AM	5	0
EXT AM	5	1
INT FM	5	2
EXT FM	5	3
RATE	5	4
MOD OFF	5	5
POS MET	5	6
NEG MET	5	7
7	3	0
8	3	1
4	3	2
5	3	3
1	3	4
2	3	5
0	3	6
.	3	7
LEFT	1	2
RIGHT	1	3
RF	1	4

KEY LABEL	LOCATION Row	Column
FREQ	4	0
LVL	4	1
???????	4	2
???????	4	3
STR	4	4
RCL	4	5
LCL	4	6
STATUS	4	7
9	2	0
MHZ/MV	2	1
6	2	2
kHz/UV	2	3
3	2	4
DBM/%	2	5
+/-	2	6
dBmV	2	7
UP	0	0
DOWN	0	1

SECTION 9
REFERENCE DRAWINGS

9.1 INTRODUCTION

This section contains the reference drawings for the Model 2410. Reference drawings are schematics, board top assembly drawings (board parts layout drawings), and assembly drawings.

Reference drawing titles may refer to "2405", "2407", "2410A", "2410A", or "2475" units, or a combination of these numbers because their associated assemblies are used in more than one of the Wavetek 2400 series of signal generators. Any drawing in this section with a "2407" or a "2405" label also is used in the 2410A unit.

A starred (*) value shown on a schematic indicates the nominal value for the particular part. A component of a slightly different value may be substituted for a starred part during calibration.

9.2 REFERENCE DRAWINGS

Schematics are numbered from Figure 9-1 to Figure 9-16. Some boards require two (2) schematics to show circuitry detail. For example, the Microprocessor Board requires two schematics (Figures 9-1 and 9-2). The board top assembly drawing (parts layout drawing) is shown on the page immediately following its associated schematic. If two schematics are used, the top assembly drawing will be shown following the first schematic. The top assembly drawing for the Microprocessor Board, for example, follows Figure 9-1, the first of the two Microprocessor Board schematics.

A schematic may show components found on several subassemblies. When this occurs, more than one assembly drawing may be required to clearly show detail. For example, the 2410 power supply requires four assembly drawings (Figures 9-15A, 9-15B, 9-15C, and 9-15D). Assembly drawings have the same numeric designator as their associated schematics. They also contain a letter suffix.

Assembly drawings are shown in Figures 9-15A through 9-15D, and 9-17 through 9-27. Each assembly drawing refers to a "Reference BOM" (Bill of Material). Each BOM is included in Section 10 of this manual as a "Parts List".

9.3 ORDER OF REFERENCE DRAWINGS

Reference drawings are located in the order listed in Table 9-1.

TABLE 9-1. ORDER OF 2410 REFERENCE DRAWINGS

Figure 9-1	SCHEMATIC, MICROPROCESSOR BD (Sheet 1 of 2)(0014-30-0420)
Figure 9-1A	TOP ASSEMBLY DWG, MICROPROCESSOR BD (0012-30-0123)
Figure 9-2	SCHEMATIC, MICROPROCESSOR BD (Sheet 2 of 2)(0014-30-0420)
Figure 9-3	SCHEMATIC, CONTROL BD (Sheet 1 of 2)(0014-30-0415)
Figure 9-3A	TOP ASSEMBLY DWG, CONTROL BD (side 1)(0012-30-0103)
Figure 9-3B	TOP ASSEMBLY DWG, CONTROL BD (side 2)(0012-30-0103)
Figure 9-4	SCHEMATIC, CONTROL BD (Sheet 2 of 2)(0014-30-0415)
Figure 9-5	SCHEMATIC, DIRECT DIGITAL SYNTHESIZER BD (0014-30-0442)
Figure 9-5A	TOP ASSEMBLY DWG, DDS BD (0012-30-0177)
Figure 9-6	SCHEMATIC, RF SYNTHESIZER BD (0014-30-0439)
Figure 9-6A	TOP ASSEMBLY DWG, RF SYNTHESIZER BD (0012-30-0175)
Figure 9-7	SCHEMATIC, VCO BD (0014-30-0430)
Figure 9-7A	TOP ASSEMBLY DWG, VCO BD (0012-30-0127)
Figure 9-8	SCHEMATIC, REFERENCE & LO BD (0014-30-0440)
Figure 9-8A	TOP ASSEMBLY DWG, REFERENCE & LO BD (Sheet 1 of 2) (0012-30-0174)
Figure 9-8B	BOTTOM ASSEMBLY DWG, REFERENCE & LO BD (Sheet 2 of 2)(0012-30-0174)
Figure 9-9	SCHEMATIC, DOUBLER BD (0014-30-0437)
Figure 9-9A	TOP ASSEMBLY DWG, DOUBLER BD (Side 1)(0012-30-0162)
Figure 9-10	SCHEMATIC, AM/DIVIDER BD (0014-30-0426)
Figure 9-10A	TOP ASSEMBLY DWG, AM/DIV BD (Side 1)(0012-30-0120)
Figure 9-11	SCHEMATIC, OUTPUT BD (Sheet 1 of 2)(0014-30-0438)
Figure 9-11A	TOP ASSEMBLY DWG, OUTPUT BD (Side 1)(0012-30-0163)
Figure 9-12	SCHEMATIC, OUTPUT BD (Sheet 2 of 2)(0014-30-0438)
Figure 9-13	SCHEMATIC, MOTHER BD (0014-30-0441)
Figure 9-13A	TOP ASSEMBLY DWG, MOTHER BD (0012-30-0176)
Figure 9-14	SCHEMATIC, KEYBOARD (0014-30-0425)
Figure 9-14A	TOP ASSEMBLY DWG, KEYBOARD (0012-30-0119)
Figure 9-15	SCHEMATIC, POWER SUPPLY (0014-30-0423)
Figure 9-15A	TOP ASSEMBLY DWG, POWER SUPPLY (0012-30-0117)
Figure 9-15B	ASSY DWG, HEATSINK (0012-10-0133)
Figure 9-15C	ASSY DWG, TRANSFORMER (0012-20-0100)
Figure 9-15D	ASSY DWG, FAN (0012-20-0101)
Figure 9-16	SCHEMATIC, REFERENCE SYNTHESIZER (0014-30-0436)
Figure 9-16A	TOP ASSEMBLY DWG, REFERENCE SYNTHESIZER (0012-30-0157)
Figure 9-17	ASSY DWG, F.P. MECH. (0012-30-0113)
Figure 9-18	ASSY DWG, FRONT PANEL (0012-30-0164)
Figure 9-19	ASSY DWG, CARD CAGE (0012-30-0115)
Figure 9-20	ASSY DWG, CARD CAGE CABLE LOCATION (0012-10-0142)
Figure 9-21	ASSY DWG, ENCLOSURE, AM/DIV AND OUTPUT, 24XX (0012-30-0131)
Figure 9-22	ASSY DWG, ENCLOSURE, RF SYNTH & DOUBLER (0012-30-0173)
Figure 9-23	ASSY DWG, ENCLOSURE, LO/REF (0012-30-0172)
Figure 9-24	ASSY DWG, BOTTOM COVER (0012-30-0126)
Figure 9-25A/B	ASSY DWG, REAR PANEL ASSY. (2 sheets)(0012-30-0125)
Figure 9-26A/B	ASSY DWG, CHASSIS ASSY. (2 sheets)(0012-30-0170)
Figure 9-27	ASSY DWG, 2410 FINAL ASSY. (0012-30-0171)

SYMBOL NOTES

Denotes DC voltage reading unless otherwise specified.

Denotes high-impedance crystal detector reading in volts unless otherwise specified.

Denotes 50 ohm crystal detector reading in volts unless otherwise specified.

Signal or voltage source.

Connects to indicated signal or voltage source.

Arrow indicates clockwise rotation of wiper.

Coaxial jack

Coaxial plug

Coaxial cable

Factory adjusted part.

Denotes a front-panel device.

Denotes a rear-panel device.

Denotes a printed circuit board adjustment or accessible module adjustment.

Denotes an internal module adjustment not accessible without removing module cover.

ABBREVIATION CODE

A	ampere	IF	intermediate frequency	Ω	ohm
AC	alternating current	J	jack	OC	opto-coupler
C	capacitor	K	relay	P	plug
ccw	counterclockwise	kHz	kilohertz	p	peak
CR	diode	kΩ	kilohm	pp	peak-to-peak
CW	continuous wave	kV	kilovolt	pF	picofarad
cw	clockwise	kW	kilowatt	Q	transistor
dB	decibel	L	inductor	R	resistor
dBc	dB referred to carrier	M	meter	RF	radio frequency
dBm	dB referred to 1 mW	MHz	megahertz	RMS	root-mean-square
dBmV	dB referred to 1 mV	MΩ	megohm	R.P.	rear panel
DC	direct current	mA	milliampere	S	switch
DS	indicating device, lamp	mH	millihenry	T	transformer
F	farad	mV	millivolt	T.P.	test point
F.P.	front panel	mW	milliwatt	V	volt
H	henry	μF	microfarad	VA	voltampere
Hz	hertz	μA	microampere	W	watt
IC	integrated circuit	μH	microhenry	X	crystal

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REV	ECN	BY	DATE	APP

TJ101

X101 3.579545 MHZ

R103 6.19M

C102 12PF

C103 12PF

R102 5.11K

R101 5.11K

C101 10µF

EXTAL XTAL

IC101 HD6303

IC102 74HC573

IC103 27C256

IC104 DY1225Y

IC105 EF6821

IC106 EF6821

IC107 74HC04

IC108 74HC04

IC109 74HC10

IC110 74HC10

IC111 74HC10

IC112 ID77130

IC113 74HC4078

IC137 LM2925

C104 0.1µF

C105 0.1µF

C106 0.1µF

C107 0.1µF

C108 1µF

C109 1µF

C110 0.1µF

C111 10µF

C112 0.1µF

C113 0.1µF

C114 0.1µF

C132 0.1µF

R104 5.11K

R105 5.11K

R106 5.11K

R107 5.11K

R108 5.11K

R109 5.11K

R110 5.11K

R111 5.11K

R112 5.11K

R113 100

R114 5.11K

R115 5.11K

R116 100

R117 100

R118 100

R119 5.11K

R120 5.11K

R121 100

R122 100

R123 100

R124 100

R125 - R135 5.11K

R136 - R144 5.11K

R145 - R148 5.11K

SW101

SW102

P102

Z6A 0 TRIP
Z6C 1 AM/DIV
Z7A 2 LO/REF
Z7C 3 SYNTH
Z8A 4 OUTPUT
Z8C 5 DEV
Z9A 6 ODD
Z9C 7 OPT

Z6C RESET

D GND

UNUSED GATES

LAST DESIG. USED

R198 C141
IC137

NOTES:

1. THE GPIB INTERFACE GROUND AND THE BOARD LOGIC GROUND ARE COMMON AT ONE POINT ONLY. (SHEET 2)

C133 - C148 ARE 0.1µF BYPASS CAPS ACROSS ALL FUNCTION ICS.

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B ABEL	DATE 86:40	WAVETEK
MATERIAL	PROJENGR E CHAN	1 FEB 1989	TITLE MFG / ENGR CHECK SET
	RELEASE APPROV S MUSSMANN		SCHEMATIC MICROPROCESSOR BD
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± XX ± ANGLES ±		
	DO NOT SCALE DWG SCALE N/A	MODEL NO 2407	DWG NO 0014-30-0420 REV C
	M.87833.RC /V7.FAB	CODE IDENT 34280	C11A SHEET 1 OF 2

0014-30-0420 C

9-4

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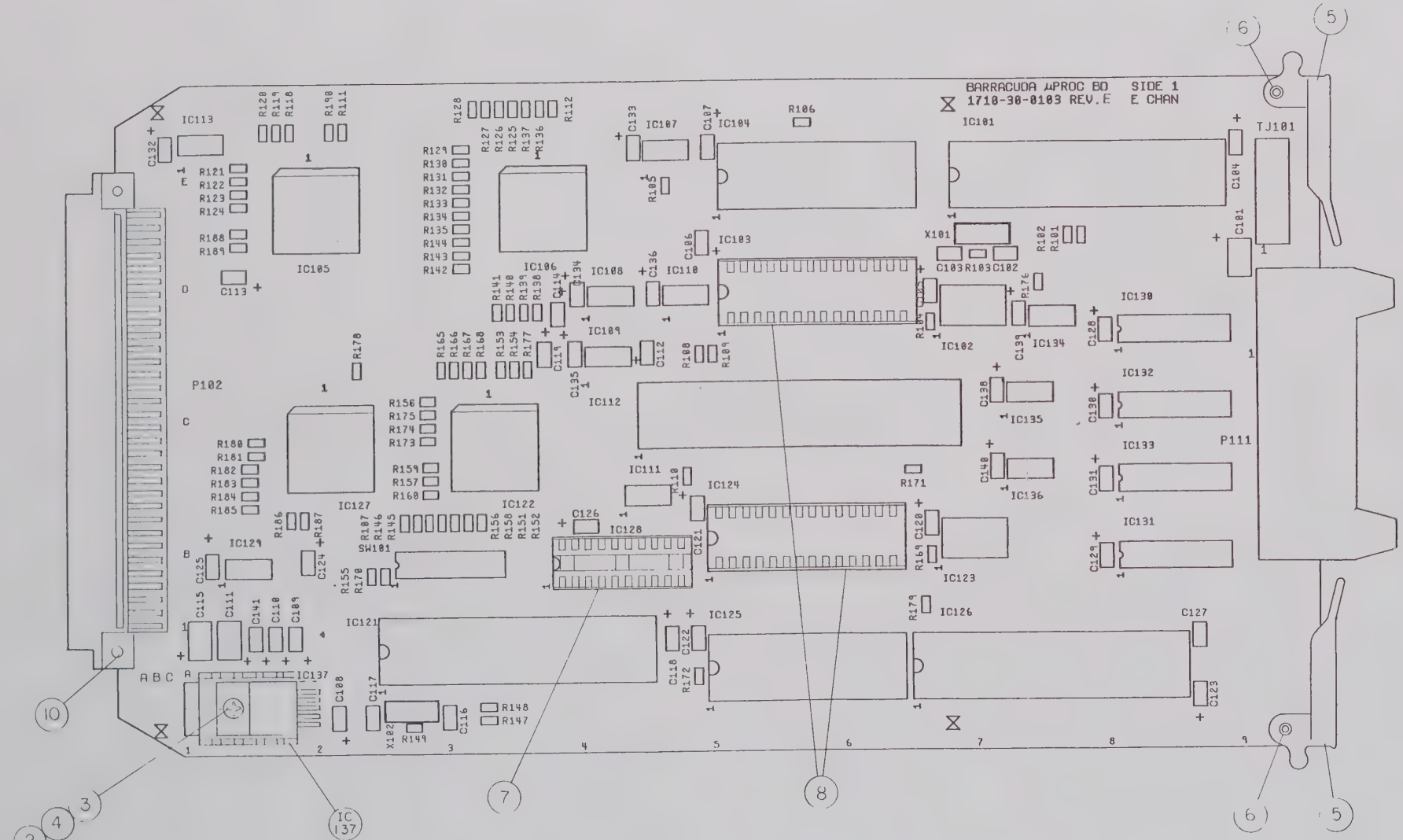
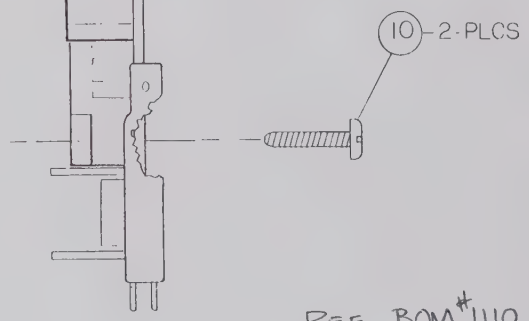
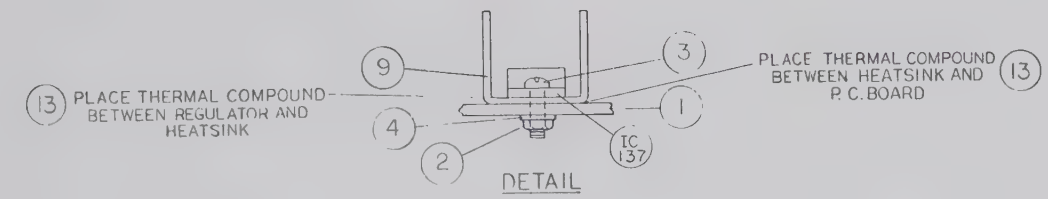
PLN	REV	ECN	BY	DATE	APP
	C	RELEASE PIN# 4731	EG	8-89	
4322	D	REDRAWN AND REF DES ADDED	[illegible]	1-90	
4944	E	REMOVE BOM 1218-00-2621	[illegible]	10/90	EK
5000	F	REMOVED ITEMS 11 & 12 CHGD ITEM 10	[illegible]	2/91	





REF BOM# 1110-00-2321 PC ASSY
#1219-00-0740 HYBRID



DETAIL

1219-00-0740	HYBRID μPROC 2407
1110-00-2321	μPROC 2407
C011-00-0019	2407 DWG LIST
NEXT ASSY	USED ON

REMOVE ALL BURRS AND BREAK SHARP EDGES
MATERIAL: SEE B.O.M.'S LISTED ABOVE
FINISH WAVETEK PROCESS: N/A
DRAWN: A. ABEL 88/48
PROJ ENGR: E. CHAN 1 FEB 1989
RELEASE APPROV: S. MUSSMANN 2/15/89
TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± XX ± ANGLES ±
DO NOT SCALE DWG
SCALE 2:1
TM 87833 RC /V7 FAB

WAVETEK
TITLE: MFG / ENGR CHECK SET
TOP ASSEMBLY DWG MICROPROCESSOR BD
MODEL NO 2407
DWG NO 0012-30-0123 REV F
CODE IDENT 34280 C2A SHEET 1 OF 1

REMOVE ALL BURRS AND SHARP EDGES	DRAWN	B ABEL	DATE	08:48
MATERIAL	PRODUCTION	E CHAN		1 FEB 1989
	RELEASE APPROVAL	S MUSSMANN		21/2/89
FINISH	TOLERANCE UNLESS OTHERWISE SPECIFIED			
WAVETEK PROCESS	SCALE N/A			
	DO NOT SCALE DWG			
	M.87033.RC V7.FRB			

WAVETEK

TITLE MFG / ENGR CHECK SET

SCHEMATIC
MICROPROCESSOR BD

MODEL NO	DWG NO	SHEET 2 OF 2	REV
24@7	001H-30-0H20		C

CODE IDENT	3428D	CL2A

001H-30-0420 C

NOTES:

1. THE GPIB INTERFACE GROUND AND THE BOARD LOGIC GROUND ARE COMMON AT ONE POINT ONLY.
2. C139 - C149 ARE 0.1uF, BYPASS GPIB ACROSS ALL FUNCTION ICS.

• NOTE 1:

LAST DESIG. USED

UNUSED GATES

P102

P111

X102 3.579545 MHZ

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REV	ECN	BY	DATE	APP

400 LEVEL

1K LEVEL

SEE NOTE 2

SEE NOTE 3

* MODEL 2407 ONLY

NOTES:
1)
2) NOT FOUND ON B.O.M.'S
3) P203 IS USED ON 2410A ONLY. NOT FOUND ON 2407 B.O.M.'S

REV	PIN NO	CHANGE	BY	DATE
F	4957	REMOVED * STAR VALUE FROM C290 AND REMOVED NOTE 1 * STAR VALUE	EK	12/1/90
E	4944	ADDED NOTES 2 AND 3 CHG IC213, ADDED C291 100 pF	EK	10/29/90
D	4937	ADDED STAR VALUE C290 1uF	EK	10/05/90
C	4782	DOCUMENTED W1 JUMPER WIRE FROM IC250 PIN 14 TO POINT 'B'	EK	11/28/89

REVISIONS

REV F

WAVETEK

TITLE CONTROL BOARD SCHEMATIC

DRAWN 6-12-89 CHKD APP

SCALE NONE

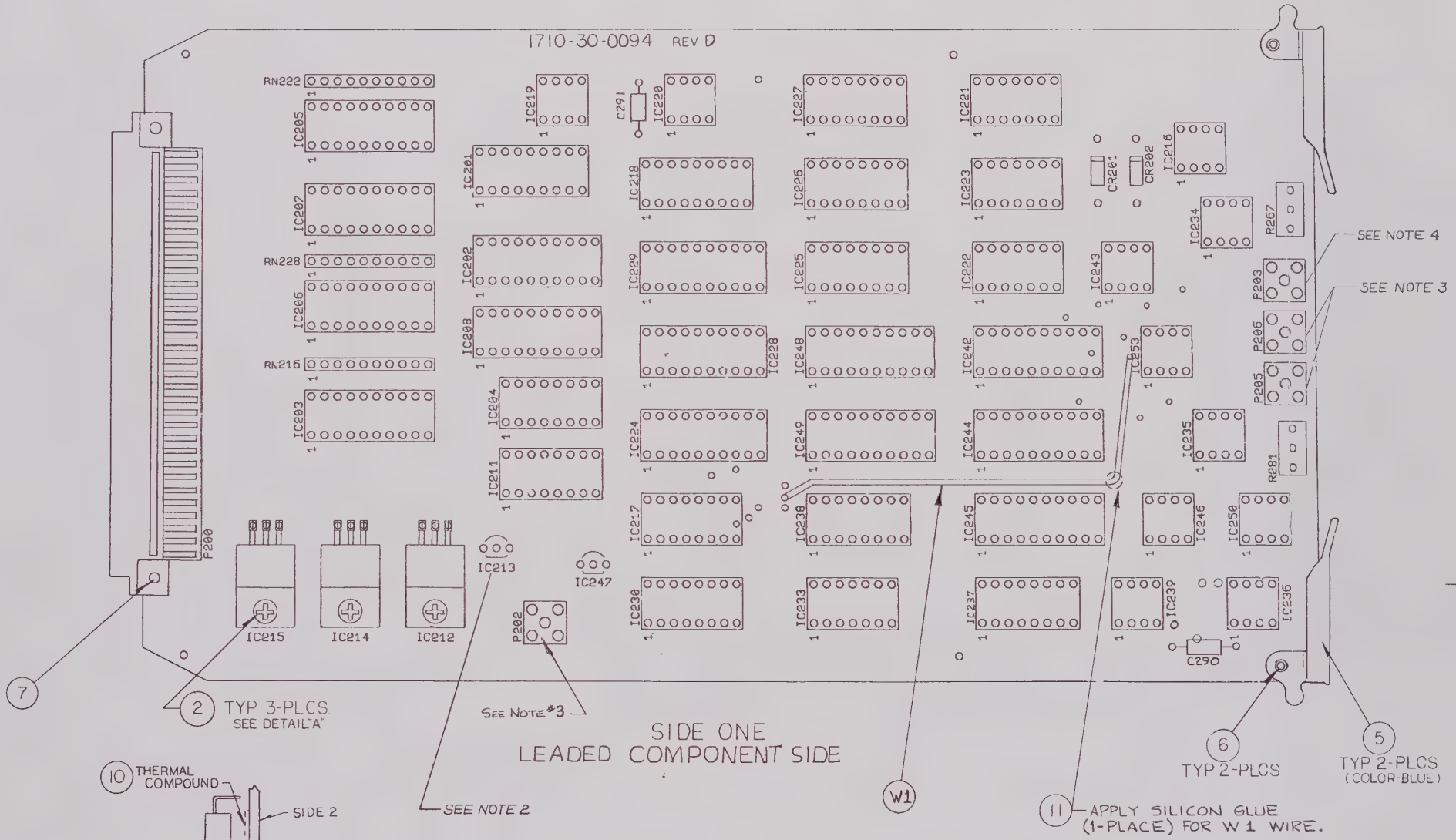
SHT 1 OF 2

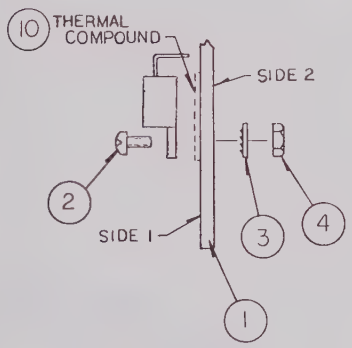
1

FILE NAME WAVE2.SCH

FILE NO. 0014-30-0415

REVISIONS				
REV	DESCRIPTION	BY	DATE	PIN
A	PERFORMANCE UPDATE		3/15/89	4602
B	RELEASE TO PRODUCTION		9/89	4751
C	MOVE JUMPER FROM SIDE 2 TO SIDE 1. MOUNT IN 2 HOLES	EK	12/89	4787
D	ADD STAR VALUE C290 1uF CAP AND CUT TRACE		10/5/90	4937
E	REMOVED BOM 1218-00-2620 ADD TCM5 10-W 11		10/29/90	4944
F	ADDED FROM BACK SIDE AND "HRM" ON TOP SIDE C290 & C291. NOW LEADED COMP. ON SIDE 1.	EK	12/6/90	4957
G	ADD ITEMS 8 & 9. CHGD ITEM 10		12/91	5000





DETAIL "A"
TYP. 3-PLCS

NOTES:
1)
2) IC213 COULD BE SMT ON SIDE 2 OR LEADED ON SIDE 1.
3) P205 P206 P202 COMPONENTS ARE SHOWN PARTS LAYOUT AND SCHEMATIC BUT ARE NOT USED ON BOMS.
4) P203 COMPONENT IS USED ON 2410A ONLY. P203 IS SHOWN ON PARTS LAYOUT AND SCHEMATIC BUT IS NOT FOUND ON B.O.M. FOR 2407.

REF B.O.M. 1219-00-0741 HYBRID KIT 2407
1219-00-0804 2410A
1110-00-2320 PC ASSY 2407
1110-00-2359 2410A

NOT ASSY USED ON	APPLICATION
1110-00-2359	2410A
1110-00-2320	2407
1219-00-0804	2410A
1219-00-0741	2407

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: FRACTIONS ± DECIMALS .XX ± .N/A ANGLES ±
MATERIAL N/A
FINISH N/A
CONTRACT NO.
APPROVALS DATE
DRAWN S. Fields 9-14-89
CHECKED E. KOHL 9/15/89

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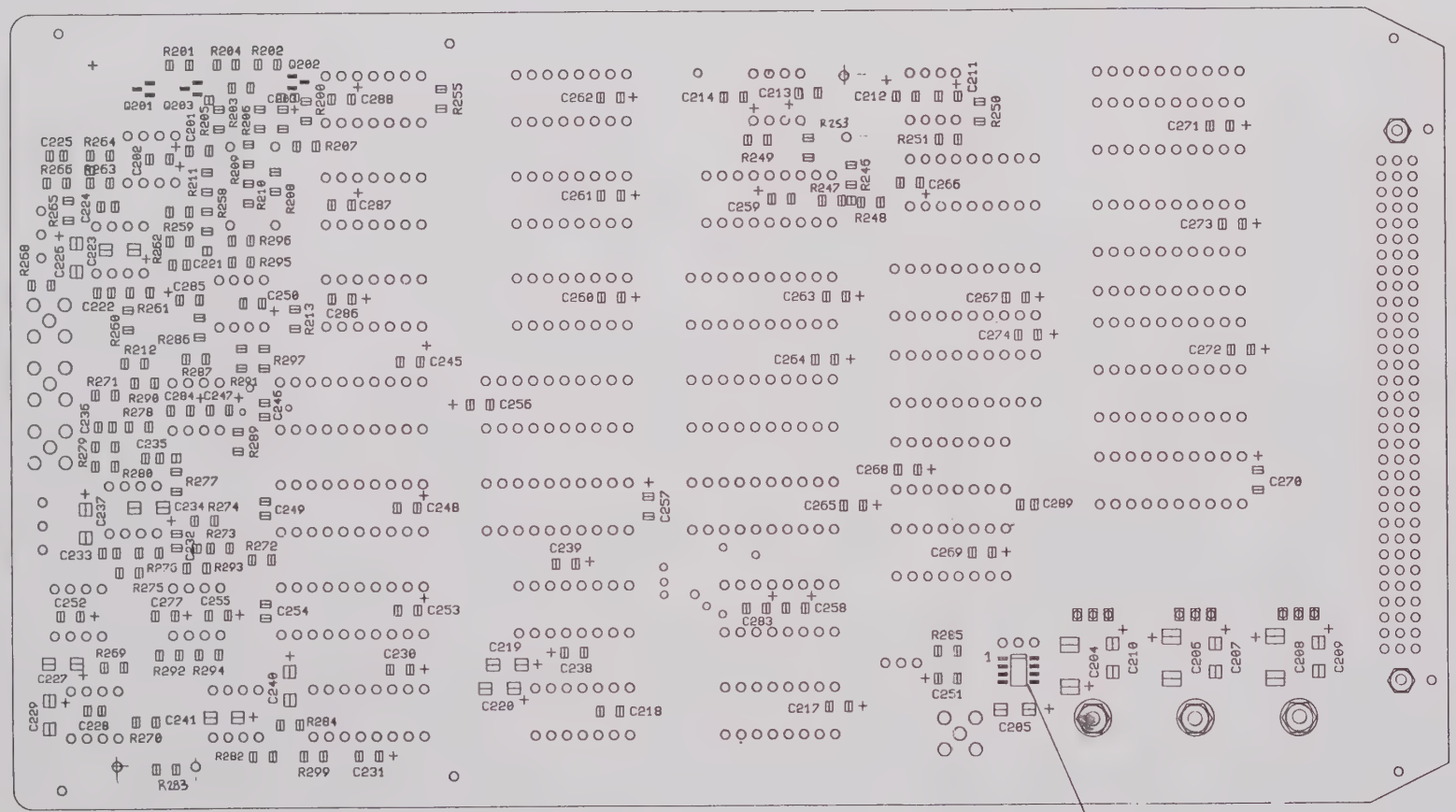
WAVETEK RF PRODUCTS, INC.
ASSY DWG CONTROL BD.
SIZE D | CODE IDENT NO. 34280 | DRAWING NO 0012-30-0103 | REV G
SCALE 2X | DO NOT SCALE DRAWING | SHEET 1 OF 2

9-8

REVISIONS			
REV	DESCRIPTION	BY	DATE
	SEE SHEET 1		



SIDE TWO
SMT

REF B.O.M. 1219-00-0741 2407
1219-00-0804 2410A
1110-00-2320 2407
1110-00-2359 2410A

1110-00-2359	2410A
1110-00-2320	2407
1219-00-0804	2410A
1219-00-0741	2407

NEXT ASSY | USED ON
APPLICATION

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ARE:
FRACTIONS DECIMALS ANGLES
± XX ± N/A ±
.XXX ±

MATERIAL: N/A
FINISH: N/A

CONTRACT NO

APPROVALS	DATE
DRAWN S. Fields	9-14-89
CHECKED E. KOHL	9/15/89

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WAVETEK RF PRODUCTS, INC.

ASSY DWG CONTROL BD.

SIZE	CODE IDENT NO.	DRAWING NO.	REV
D	34280	0012-30-0103	F

SCALE 2X | DO NOT SCALE DRAWING | SHEET 2 OF 2

NEXT ASSY	USED ON
1110-00-2359	2410 A
1219-00-0804	2410 A
1110-00-2320	2407
1219-00-6741	2407

WAVETEK			
TITLE	CONTROL BOARD SCH.		REV F
DRAWN	6-12-89	CHKD	APP
SCALE	NONE	FILE NAME	WAVE3.SCH
SHT 2 OF 2	2	FILE NO.	0014-30-0413

SEE NOTE 2
SHT 1 OF 2

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REV	ECN	BY	DATE	APP

P101
CARRY OUT 10MHZ
RUN/CLR
CARRY IN
10MHZ RETURN

IC135 74HC04 · IC136 74F08 · IC137 74HC08 · IC138 74F08 · IC139 74HC74 · IC140 74F74 · IC141 74F86 · IC142 74HC86 · IC143 74HC86 · IC144 74HC86 · IC145 74HC86 · IC146 74HC86 · IC147 74HC86 · IC148 74F74

IC100 74HC157 · IC101 74HC157 · IC102 74HC138 · IC103 74HC541 · IC104 74HC574 · IC105 74HC574 · IC106 74HC574 · IC107 74HC574 · IC108 74HC574 · IC109 74HC574 · IC110 74HC574 · IC111 74HC574 · IC112 74HC574 · IC113 74F583 · IC114 74F583 · IC115 74HC583 · IC116 74HC583 · IC117 74F583 · IC118 74HC583 · IC119 74HC583 · IC120 74HC583 · IC121 74HC273 · IC122 74HC273 · IC123 74HC273 · IC124 74HC273 · IC125 CY7C263-55PC · IC126 CY7C263-55PC · IC127 74HC574 · IC128 74HC574

R100 5.62K · R101 4.75K · R102 4.42K · R103 4.75K · R104 4.75K · R105 – R108 4.75K TYP. · R109 – R112 4.75K TYP · R113 – R116 4.75K · R117 4.75K · R120 4.75K · R121 4.75K · R122 4.75K · R123 4.75K · R124 4.75K · R125 4.75K · R126 4.75K · R127 4.75K · R128 4.75K · R129 4.75K · R131 4.75K · R132 4.75K · R133 4.75K · R138 4.75K · R147 4.75K

C100 – C147 0.1µF

CARD ID: IC103
31 HEX

HIGH BYTE
SUMCHECK: 001D8CC7

LOW BYTE
SUMCHECK: 001B91B8

BYPASS CAPS ACROSS
IC135 – IC141 IC142 – IC144
C162 – C168 0.1µF
C145 – C147 0.1µF

UNUSED GATES

C70 SHEET 23
BIT1 BIT2 BIT3 BIT4 BIT5 BIT6 BIT7 BIT8
BIT9 BIT10 BIT11 BIT12
10MHZ

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN G ABEL	DATE 19 12 1990	WAVETEK
MATERIAL	PROJENGR T MATHEWS		TITLE SCHEMATIC DDS BD.
FINISH WAVETEK PROCESS	RELEASE APPROV E GAINES		
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± ANGLES XX ± °		
	DO NOT SCALE DWG	MODEL NO 2410A	DWG NO [illegible] REV A
	SCALE N/A TM 88016.R2 /012 FAB	CODE IDENT 34280	SIZE D SHEET 1 OF 2

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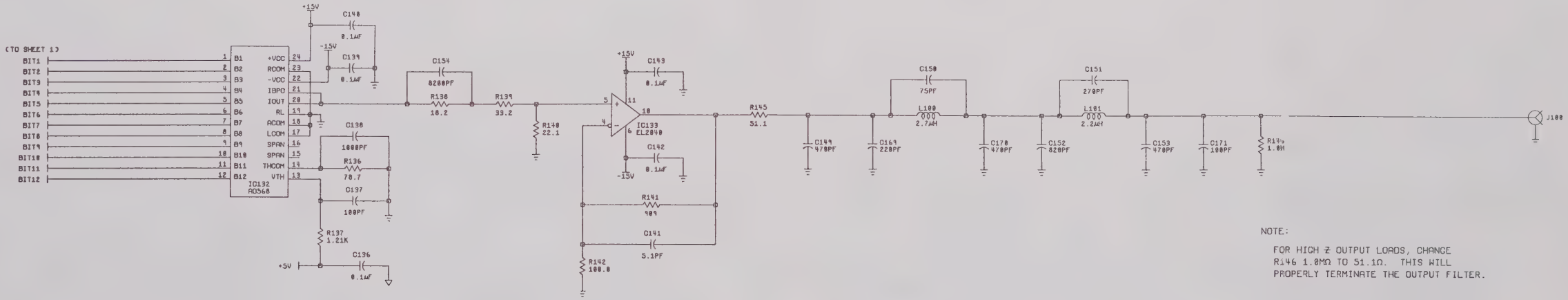
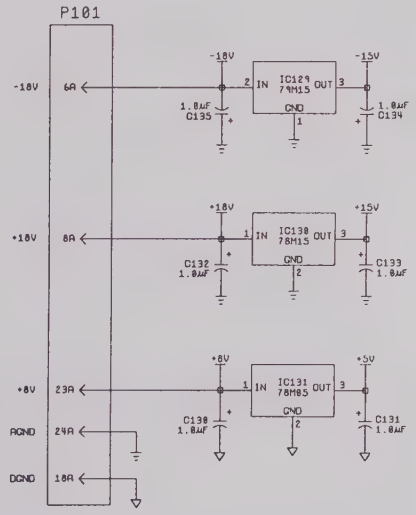
REV	ECN	BY	DATE	APP



NOTE:

FOR HIGH Z OUTPUT LOADS, CHANGE R146 1.0MΩ TO 51.1Ω. THIS WILL PROPERLY TERMINATE THE OUTPUT FILTER.



ANALOG GND AND DIGITAL GND TIED TOGETHER AT THIS POINT.

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B ABEL	DATE 19:12	WAVETEK
MATERIAL	PROJENGR T MATHEWS	26MAR 1998	TITLE MFG / ENGR CHECK SET SCHEMATIC DDS BD.
FINISH WAVETEK PROCESS	RELEASE APPROV E GAINES		
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX± ANGLES XX± ±		
	DO NOT SCALE DWG	MODEL NO 2410A	DWG NO [illegible] REV A
	SCALE N/A	CODE IDENT 34280	SIZE D SHEET 2 OF 2
	TM.89816.R2 /V12.FAB		

9-12

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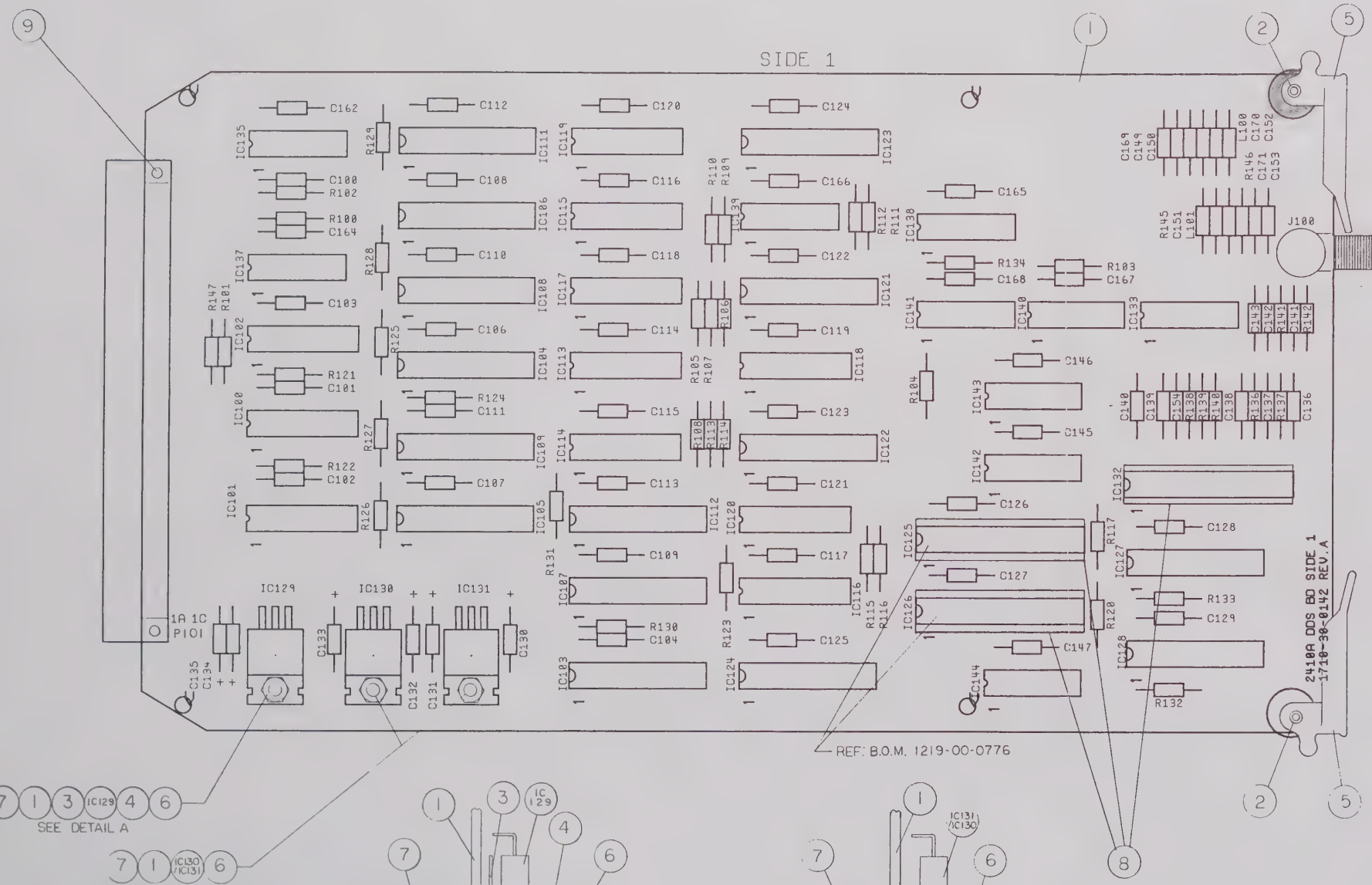
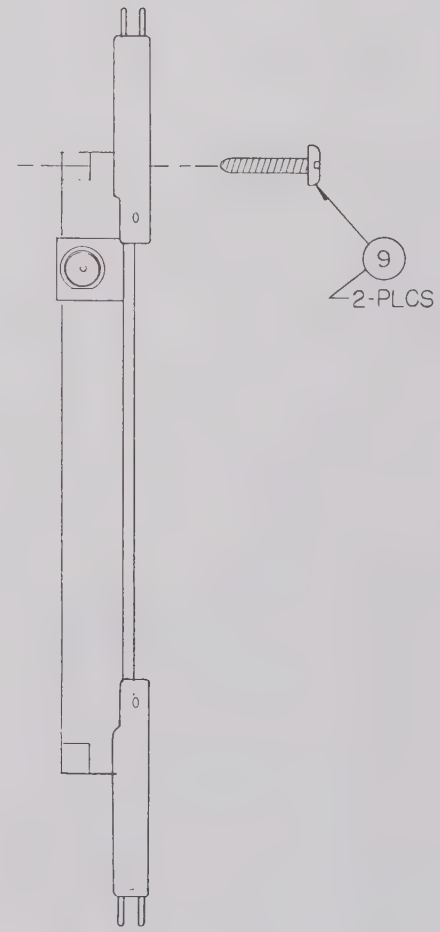
PIN	REV	ECN	BY	DATE	APP
4928	A	Release to Prod	EG	9/90	
5000	B	ADDED ITEM 9	[illegible]	2/91	





REF B.O.M. 1110-00-2336
1218-00-2627
1219-00-0776

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN [illegible] DATE 9/90	WAVETEK
MATERIAL SEE B.O.M'S LISTED	PROJ ENGR E GAINES	TITLE MFG / ENGR CHECK SET
	RELEASE APPROV	PARTS LAYOUT DWG. DDS BD.
FINISH WAVETEK PROCESS N/A	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± N/A ° XX ±	
	DO NOT SCALE DWG	MODEL NO 2410A / DWG NO 0012-30-0177 / REV B
	SCALE 2:1	CODE IDENT 34280 / SIZE C2A / SHEET 1 OF 1
	FM.89816.R1 /V11 FAB	

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REV	ECN	BY	DATE	APP
0	PROTOTYPE	5/98	R.K	
1	ENG CHANGES	7/98	R.K	
4938 A	RELEASE TO PROD.	7/98	R.K	E.G

P401

J502 REF IN

J501 RF OUT

IC484 74HC574 · IC485 74HC574 · IC486 74HC541 · IC487 MC145146 · IC488 MC145146 · IC489 74HC283 · IC488 74HC138

IC481 78M05 · IC482 78M15 · IC483 79M15

IC410 MC12889P · IC416 MC12013P · IC413 DG303A · IC414 AD7528 · IC419 DG201

IC423 74HC00 · IC501 IM1435 · IC411 TL082 · IC417 TL082 · IC417 TL082 · IC418 LM324 · IC416 LM324 · IC502 VTUNE VCO

IC421 NE5205 · IC422 NE5205 · IC428 NE5205

Q483 · Q484 2N3467 · Q485 2N2907A · Q482 2N2222A

CR401 1N914 · CR402 1N914 · CR403 1N5231 · CR404 1N914

L485 10μH · L486 1μH · L484 1μH

CONNECTED AT P401 ONLY

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN R KORRECK · DATE 6:11
MATERIAL	PROJ ENGR C GAINES · DATE 10 JUL 1998
FINISH WAVETEK PROCESS	RELEASE APPROV · TOLERANCE UNLESS OTHERWISE SPECIFIED XXX± XX± ANGLES ± · DO NOT SCALE DWG · SCALE N/A
	TM.9880A.R1 /V1.FAB

WAVETEK

TITLE MFG / ENGR ONLY SET

SCHEMATIC
RF SYNTHESIZER BD

MODEL NO 2410A · DWG NO 0014-30 0439 · REV A

CODE IDENT 34280 · SIZE A11H · SHEET 1 · OF 1

0014-30-0439 A

9-14

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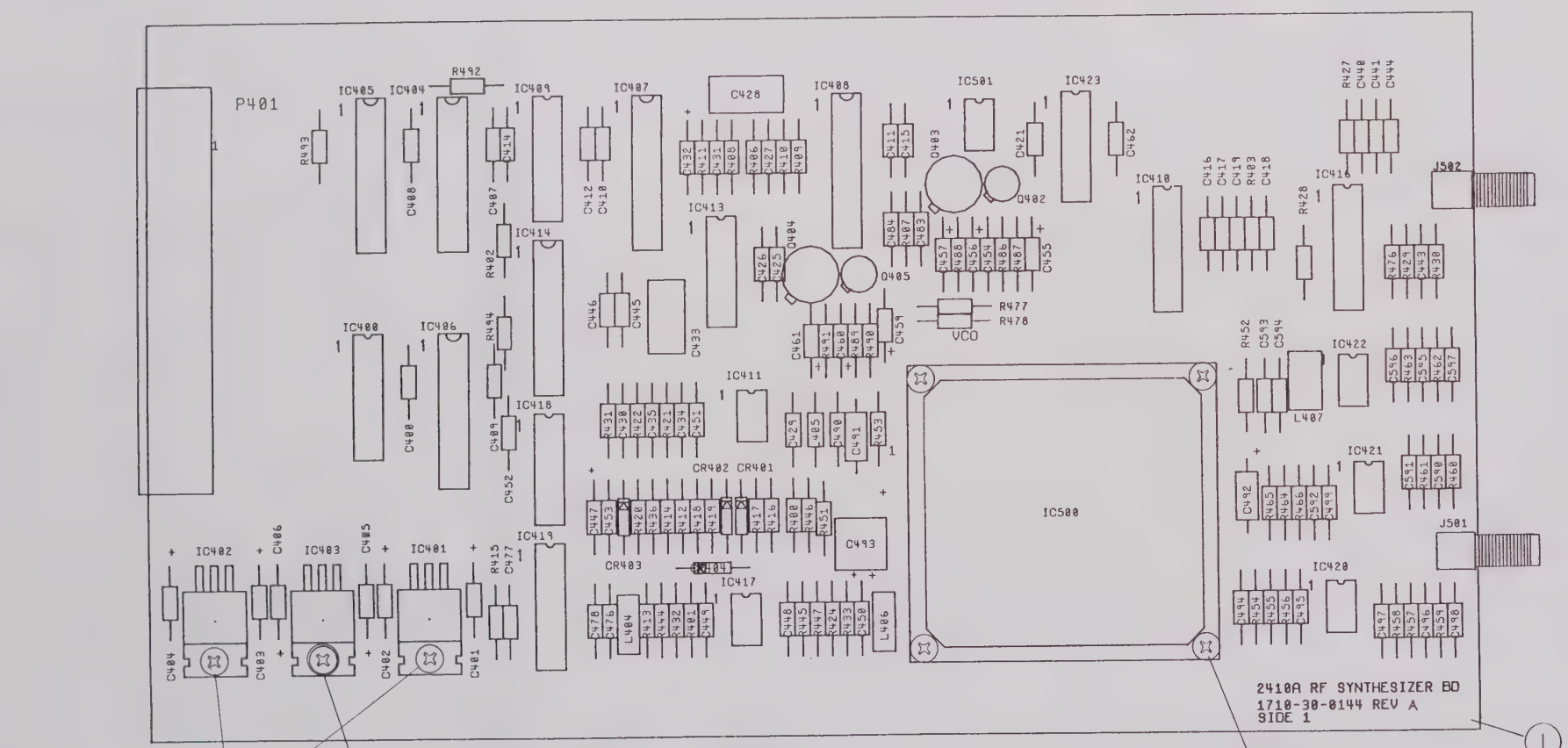
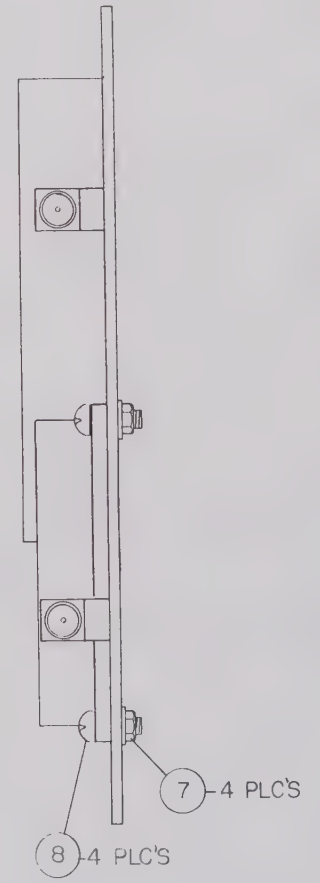
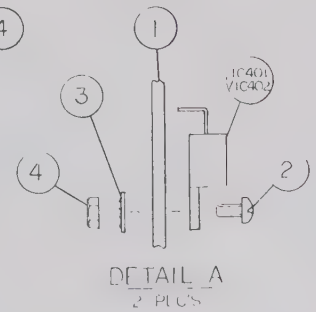
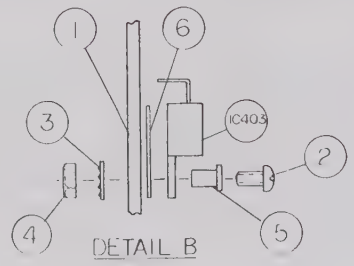
PIN	REV	ECN	BY	DATE	APP
4938	A	RELEASE TO PROD.	EG	9/90	

SIDE 1









IIIC-00-2337	PC ASSY
NEXT ASSY	USED ON

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN Fields	DATE 9/90	WAVETEK
MATERIAL SEE BOM'S LISTED	PROJENGR E. GAINES		TITLE MFG / ENGR CHECK SET PARTS LAYOUT DWG RF SYNTHESIZER BD
FINISH WAVETEK PROCESS N/A	RELEASE APPROV	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX± ANGLES ± XX±	MODEL NO 2410A
	DO NOT SCALE DWG	DWG NO 0012-30-0175	REV A
	SCALE 1:1	M 10004.R0 /V1.FAB	CODE IDENT 34260
		SHEET 1 OF 1	

0012-30-0175 A

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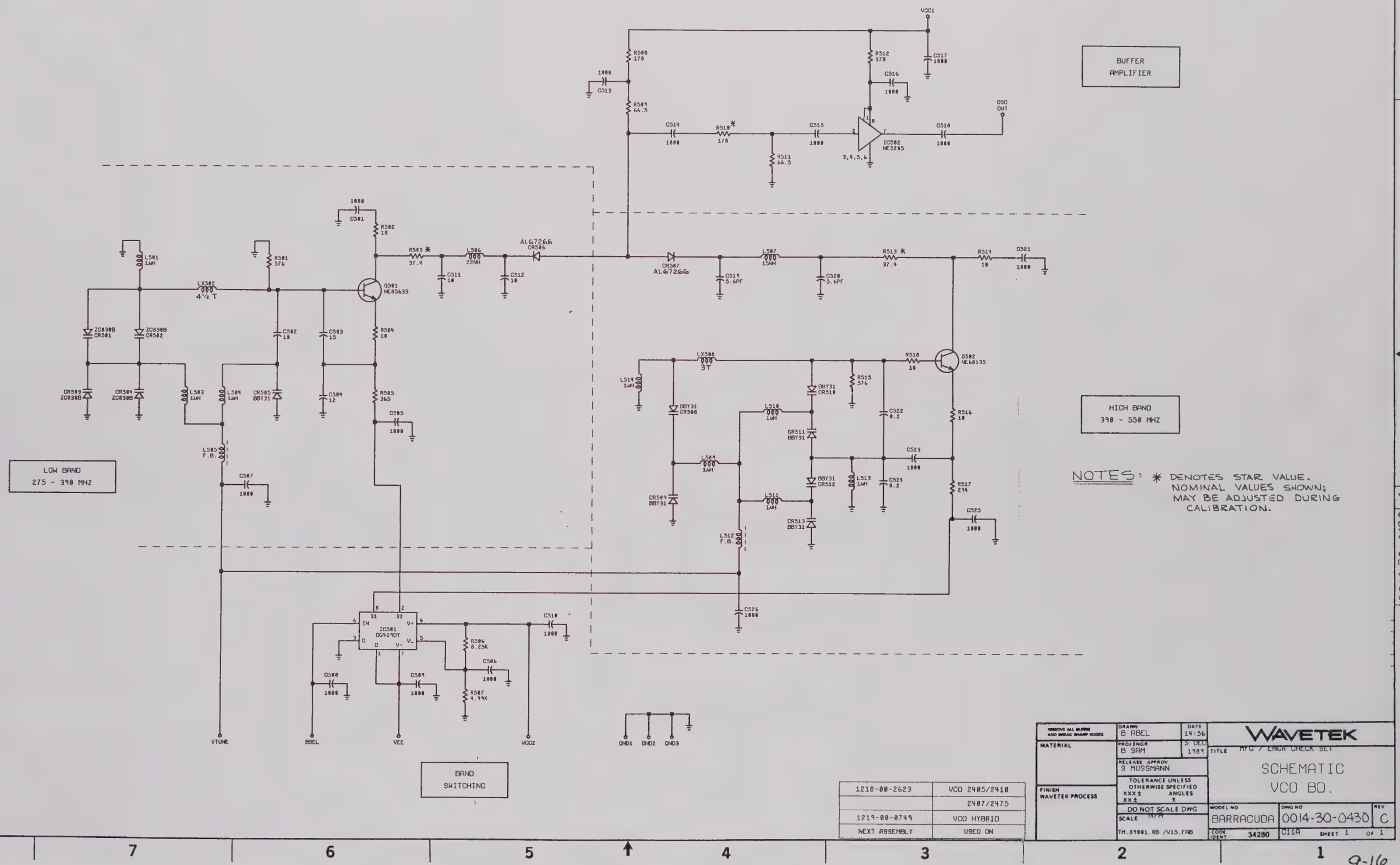
REV	ECN	BY	DATE	APP
PIN#4642	A WIDEN LANDS SHORTEN PATHS	E.K	1-17-89	
PIN#4692	B PERFORMANCE IMPROVE ADDED NOTES	E.K	9-13-89	
4829	C ADDED STAR VALUES CH6. CR506 & CR507	EK	11/1/89	



NOTES: * DENOTES STAR VALUE. NOMINAL VALUES SHOWN; MAY BE ADJUSTED DURING CALIBRATION.

1218-00-2623	VCO 2405/2410
	2407/2475
1219-00-0749	VCO HYBRID
NEXT ASSEMBLY	USED ON

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B ABEL	DATE 14:56 5 DEC 1989
MATERIAL	PROJENGR B SAM	
	RELEASE APPROV S MUSSMANN	
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± ANGLES XX ± ±	
	DO NOT SCALE DWG	
	SCALE N/A	
	TM.89001.RB /V15.FAB	

WAVETEK

TITLE MFG / ENGR CHECK SET

SCHEMATIC VCO BD.

MODEL NO	DWG NO	REV
BARRACUDA	0014-30-0430	C

CODE IDENT 34280 | CIIA | SHEET 1 OF 1

0014-30-0430 C

9-16

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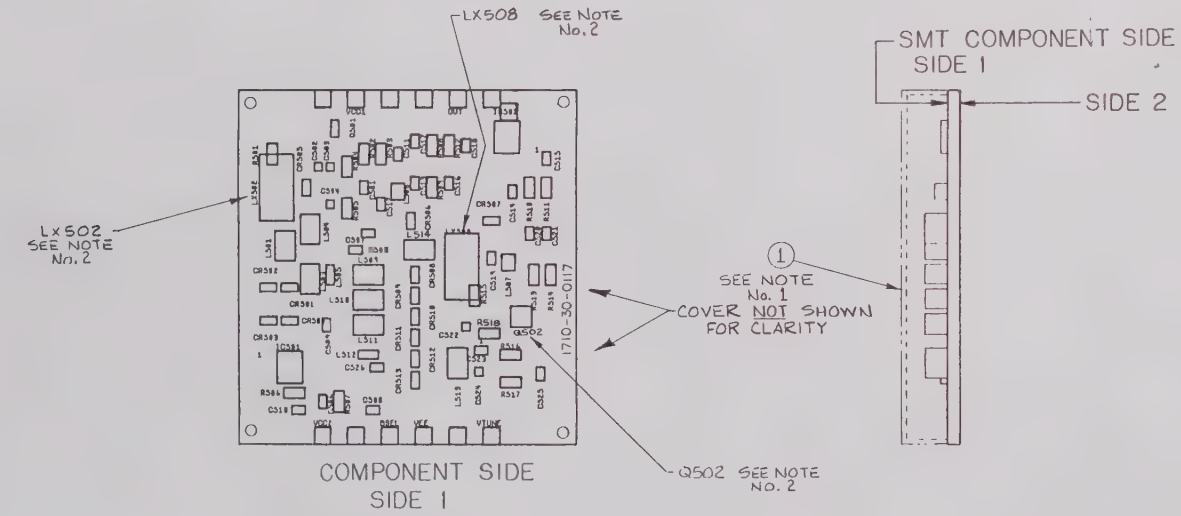
REV	ECN	BY	DATE	PIN
B	PER PIN RELEASE	DW	5-89	4731
C	RELOCATED R516, R518 C523, C522,	TGB	11/6/90	4829



NOTES:

1) COVER (ITEM 1) NOT SHOWN FOR CLARITY. COVER IS NOT TO BE INSTALLED ON VCO BOARD ASSEMBLY P/N 1218-00-2623 UNTIL THIS ASSEMBLY IS ATTACHED TO THE PC. ASSY. SYN. BOARD P/N 1110-00-2315. COVER MAY BE INSTALLED AFTER THE SYNTHESIZER ASSY. HAS BEEN TESTED BY THE TECH.
2) COMPONENTS LX502, LX508 AND Q502 ARE NOT TO BE ASSEMBLED IN THE P.C. ASSEMBLY AREA. THEY ARE TO BE INSTALLED BY T/M ASSEMBLY LINE.

REF BOM #1218-00-2623
REF BOM #1219-00-0749 HYBRID PTS

	2410/2475
1218-00-2623	2405/2407
1219-00-0749	VCO HYBRID
NEXT ASSEMBLY	USED ON

REMOVE ALL BURRS AND BREAK SHARP EDGES
MATERIAL: SEE B.O.M. LISTED ABOVE
FINISH WAVETEK PROCESS: N/A
DRAWN: B ABEL — DATE: 19:18 19 JAN 1989
PROJENGR: B SAM
RELEASE APPROV: S MUSSMANN
TOLERANCE UNLESS OTHERWISE SPECIFIED: XXX ± N/A ANGLES ± N/A; XX ± N/A
DO NOT SCALE DWG
SCALE 2:1
TM.89881.RA /V12.FAB

WAVETEK
TITLE: MFG / ENGR CHECK SET
TOP ASSEMBLY DWG VCO BD
MODEL NO 2407 — DWG NO 0012-30-0127 — REV C
CODE IDENT 34280 — C2A — SHEET 1 OF 1

0012-30-0127 C

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REV	ECN	BY	DATE	APP
PIN				
B	PROTOTYPE	R.K	5/90	
4938 A	RELEASE TO PROD.	R.K	10/90	

P601

LO UNLOCK 26
10MHZ RET 4
10MHZ REF 3
1MHZ REF 5
1MHZ RET 6
LO ENABLE
RFD7 8
RFD6 9
RFD5 10
RFD4 11
RFD3 12
RFD2 13
RFD1 14
RFD0 15
DIG GND 7
SEL2 27
RFA0 39
RFA1 33
OPT REF IN 2
GND 10
GND 36
+5V 1
+8V 16
+8V 35
+18V 19
+18V 37
-18V 17

IC687 74HC138
IC684 74HC574
IC683 74HC574
IC686 74HC541
IC688 78M05
IC618 78M15
IC611 79M15
IC601 MC145146
IC602 MC12873
IC688A TL082
TL082 IC688B
IC603 M9A0284
IC619 M9A0284
IC612 TL082
TL082 IC612
IC613 M9A0484

Q601 BS980C
Q602 2N3904
Q603 NE68133
Q604 BS980C
Q605 BS980C
Q606 2N3906
Q607 2N3904
Q608 2N3904
Q609 2N3467
Q610 2N2907A
Q611 BS979C

CR601 1N914
CR602 1N5321
CR603 1N914
CR604 1N914
CR605 BB731
CR606 HP3880
CR607 HP3880

INT/EXT
L.O. OUT TO OUTPUT BD.
INTREF OUT
EXTREF IN
TCXO Y601
VCO-

UNUSED GATE

NEXT ASSEMBLY	USED ON

REMOVE ALL BURRS AND BREAK SHARP EDGES
MATERIAL
FINISH WAVETEK PROCESS
DRAWN K KORRECK 8/91
PROJENGR L GAINES 1998
RELEASE APPROV
TOLERANCE UNLESS OTHERWISE SPECIFIED XXX± XX± ANGLES ±
DO NOT SCALE DWG
SCALE NONE
T9.9885.R8 /V1.FAB

WAVETEK
MFG / ENGR CHECK SET
TITLE
SCHEMATIC
REFERENCE & LO BD

MODEL NO 410A
DWG NO 0014-30-0440
REV A
CODE IDENT 34280
SIZE D
SHEET 1 OF

0014-30-0440 A

9-18

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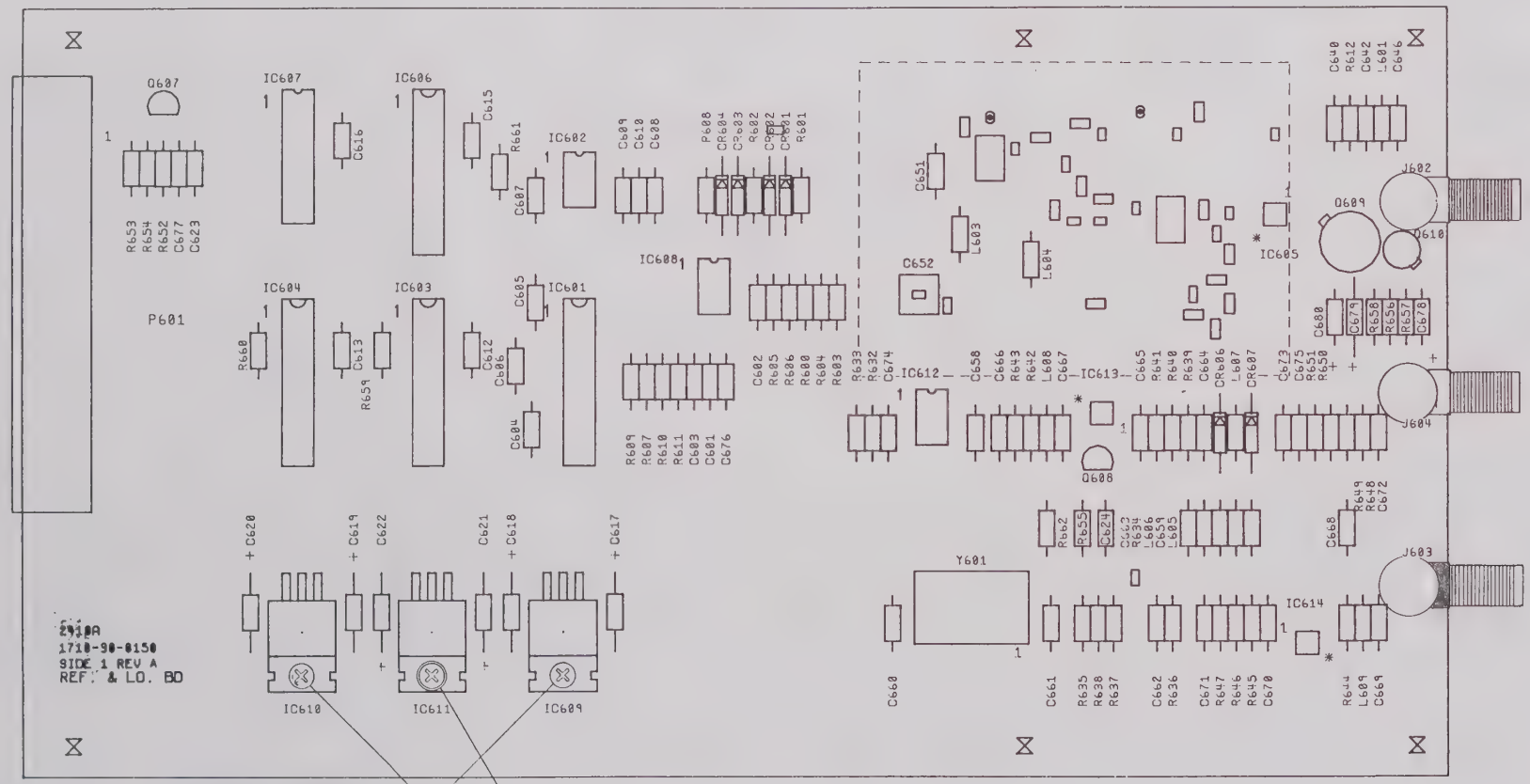
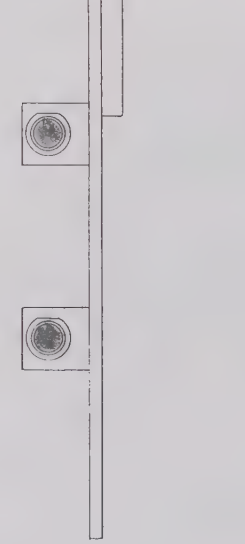
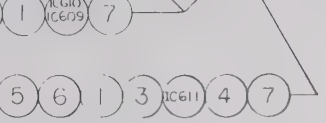
PIN	REV	ECN	BY	DATE	APP
4938	A	Release to Prod.		9/90	

LEADED COMPONENT SIDE
SIDE 1







DETAIL A

DETAIL B

1219-00-0174	HYBRID PTS KIT	REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN Fields 9/90
1110-00-2335	P.C. ASSY	MATERIAL SEE B.O.M.'S LISTED	PROJENGR E. GAINES
NEXT ASSY	WHERE USED	FINISH WAVETEK PROCESS N/A	RELEASE APPROV
			TOLERANCE UNLESS OTHERWISE SPECIFIED XXX± N/A ANGLES XX± ±
			DO NOT SCALE DWG
			SCALE 2:1

WAVETEK

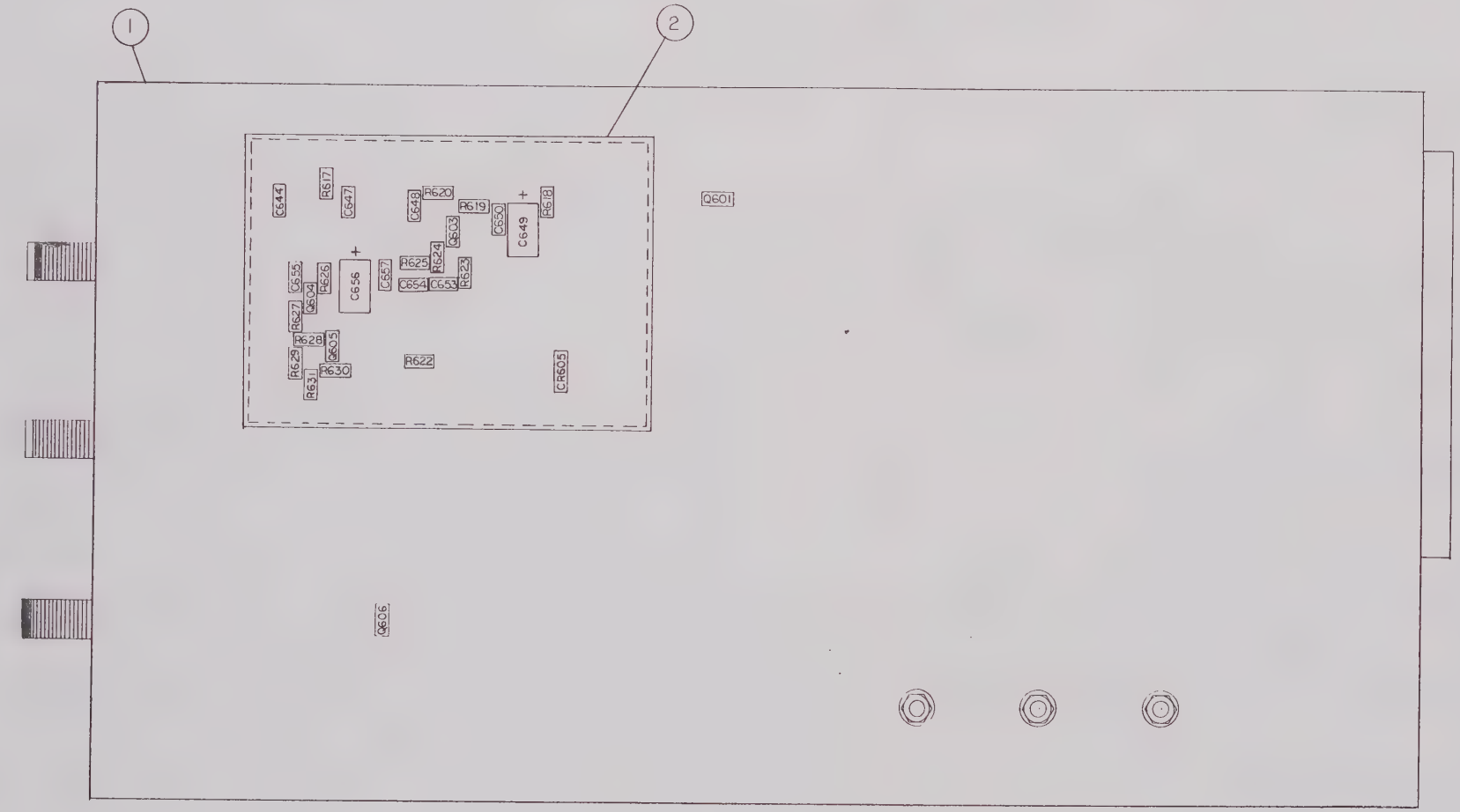
TITLE MFG / ENGR CHECK SET
PARTS LAYOUT DWG
REFERENCE & LO BD

MODEL NO	DWG NO	REV
2410A	0012-30-0174	A

CODE IDENT 34280 SIZE A SHEET 1 OF 2

0012-30-0174 A

REVISIONS				
REV	DESCRIPTION	BY	DATE	P.I.N.
A	see sheet 1			



SMT COMPONENT SIDE
SIDE 2

1219-00-0774	HYBRID KIT
1110 00-2335	PC ASSY
NEXT ASSY	USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ARE:
FRACTIONS DECIMALS ANGLES
± .XX ± ±
.XXX ±

MATERIAL: SEE B.O.M.'S LISTED

FINISH: N/A

CONTRACT NO.

APPROVALS	DATE
DRAWN	9/90
CHECKED E GAINES	

2410A

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REFERENCE & LO BOARD

SIZE	CODE IDENT NO.	DRAWING NO.
D	34280	0012-30-0174

SCALE 2X | DO NOT SCALE DRAWING | SHEET 2 OF 2

9-20

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REV	ECN	BY	DATE	APP
0	PROTOTYPE	ABEL	4/89	
1	ENG. CHANGES	ABEL	7/89	
A	RELEASED DELETE 4 HOLES	ABEL	9/89	
B	CHG. IC508 TO 78L05	RK	10/90	

J1500
RF IN
FROM SYNTH BD
275 - 550 MHZ

J1501
RF OUT
TO AM/DIV BD
275 - 1100 MHZ

P1500

1219-00-1768	HYBRID PARTS KIT
NEXT ASSEMBLY	USED ON

REMOVE ALL BURRS AND BREAK SHARP EDGES
MATERIAL
FINISH
WAVETEK PROCESS

DRAWN B HOEL 11 03
PROJENGR M GETTER 28OCT 1990
RELEASE APPROV S MUSSMANN
TOLERANCE UNLESS OTHERWISE SPECIFIED
XXX± ANGLES
XX± X
DO NOT SCALE DWG
SCALE N/A
M 89013 RB /V2 FAB

WAVETEK
MFG / ENGR CHECK SLP
TITLE
SCHEMATIC
DOUBLER BD.

MODEL NO 2410
DWG NO 0014-30-0437
REV B
CODE IDENT 34280
SIZE D
SHEET 1 OF 1

0014-30-0437

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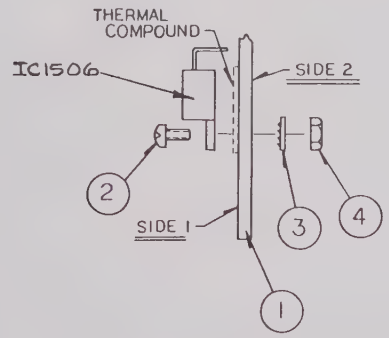
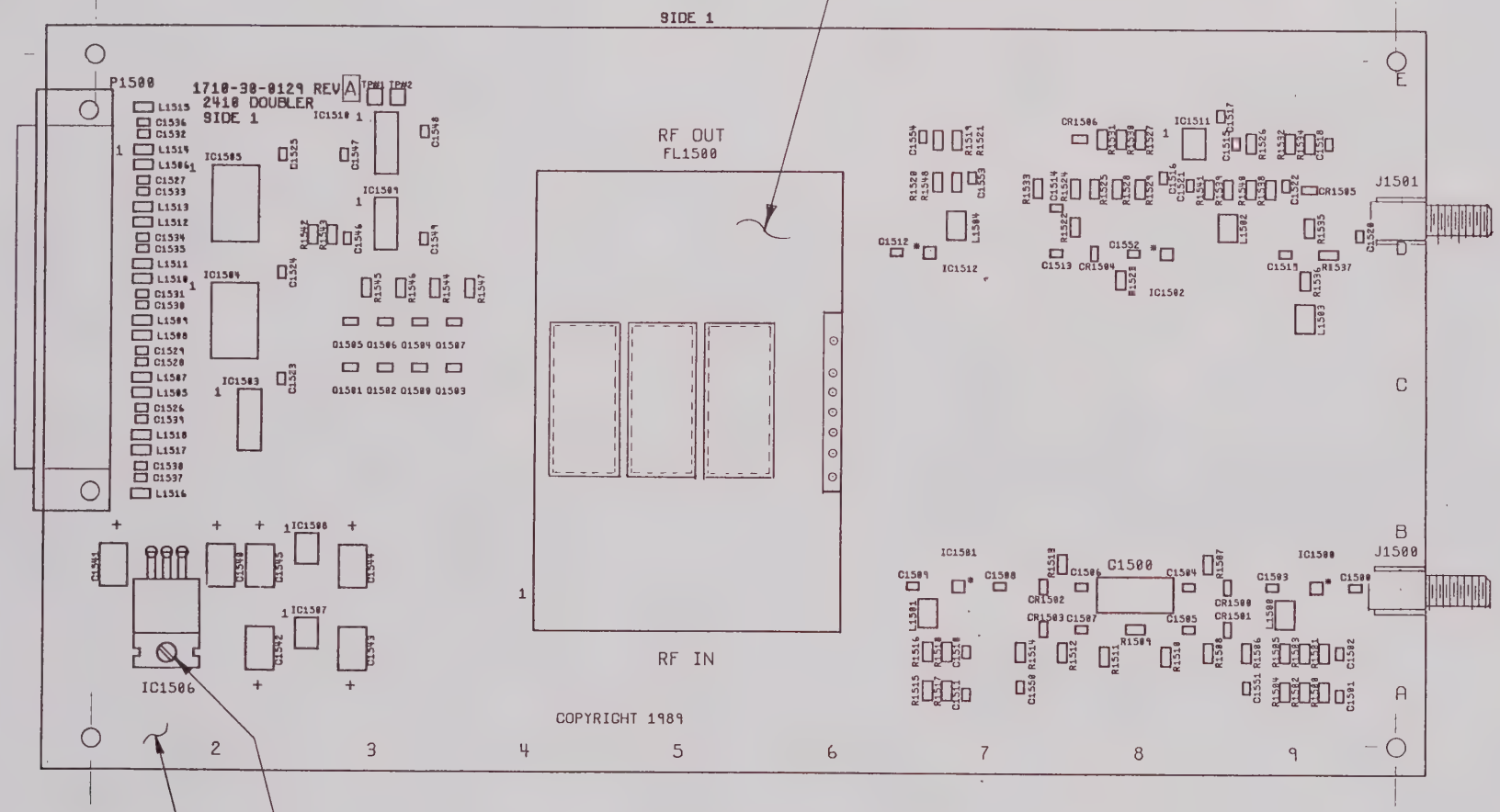
REV	ECN	BY	DATE	APP

PIN NO	REV	CHANGE	BY	DATE	APP.
4756	A	RELEASE TO PRODUCTION	EK	10/9/89	

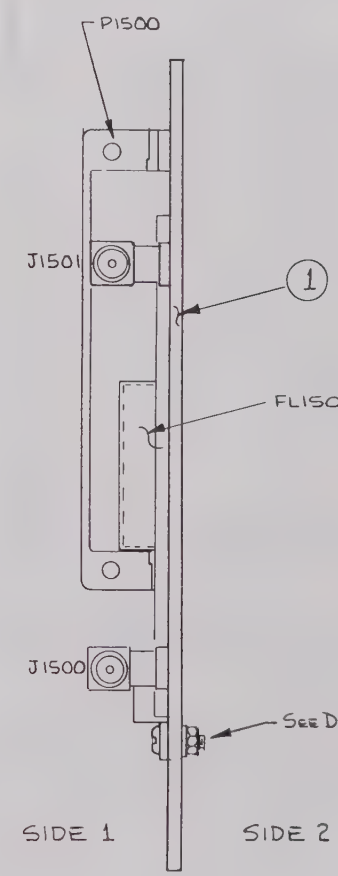


DETAIL "A"
2X SIZE

HAND SOLDER FL1500
DO NOT WAVE SOLDER



SMT / LEADED SIDE
COMPONENT SIDE
SIDE 1

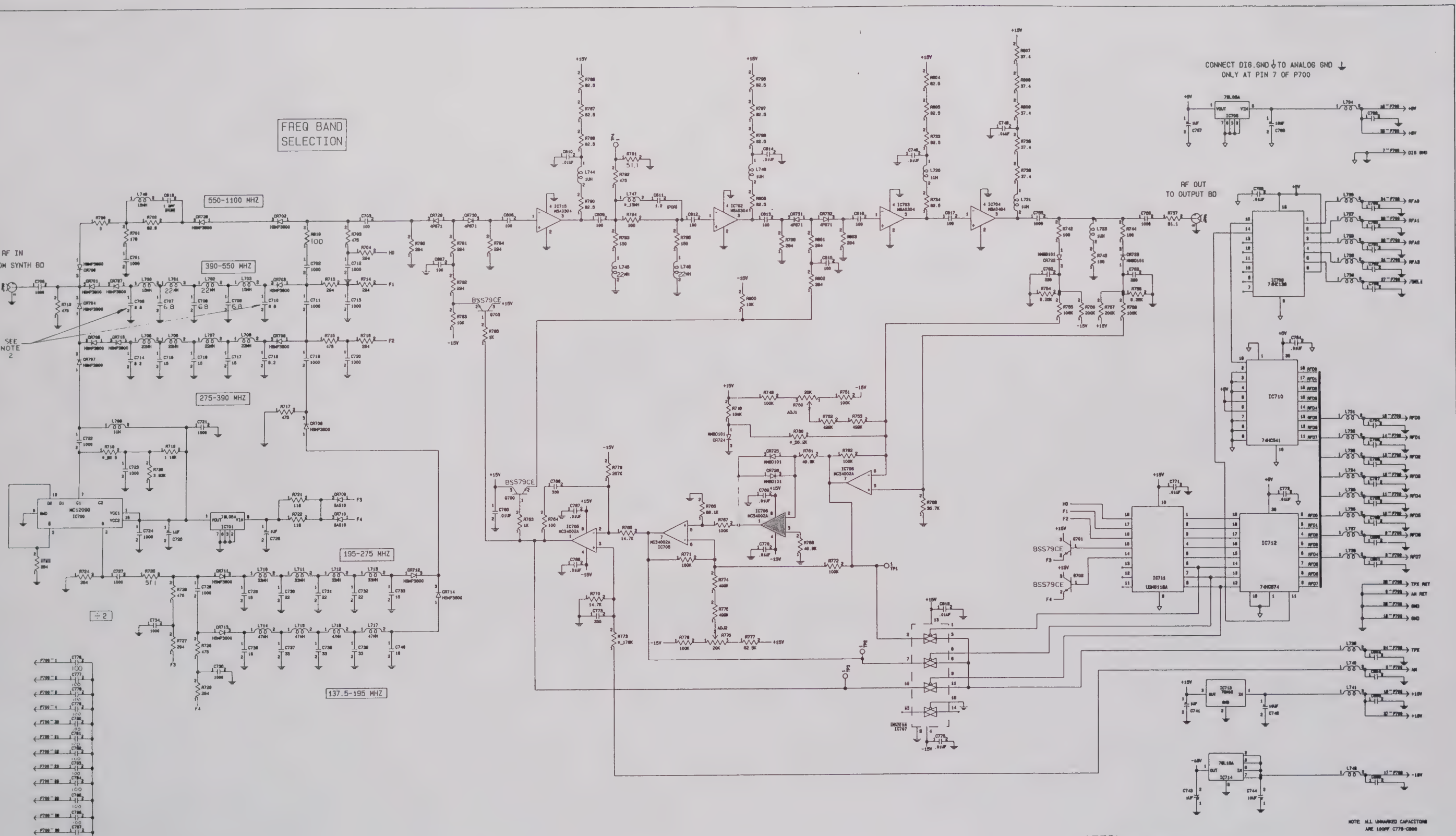


REF BOM 1110-00-2332
REF BOM 1219-00-0768

1110-00-2332	2410R PC ASSY.
1219-00-0768	HYBRID PARTS KIT
NEXT ASSEMBLY	USED ON

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN ED KOHL	DATE 10/9/89	WAVETEK
MATERIAL SEE BOMS LISTED	PROJ ENGR		TITLE MFG / ENGR CHECK SET ASSEMBLY DWG SIDE 1 DOUBLER BD
	RELEASE APPROV		
FINISH WAVETEK PROCESS NONE	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX± NA ANGLES XX± NA		
	DO NOT SCALE DWG	MODEL NO. 2410	DWG NO. 0012-30-0162 REV A
	SCALE 2:1	CODE IDENT 34280	SHEET 1 OF 1
	TM.89813.RA /V18.FAB		

9-22



NOTES:

1) * NOMINAL VALUE INDICATED, MAY BE ADJUSTED DURING CALIBRATION
2) C706, C710 ARE SHOWN ON SCHEMATIC AND PARTS LAYOUT BUT ARE NOT INSTALLED AT THIS TIME ON B.O.M.S

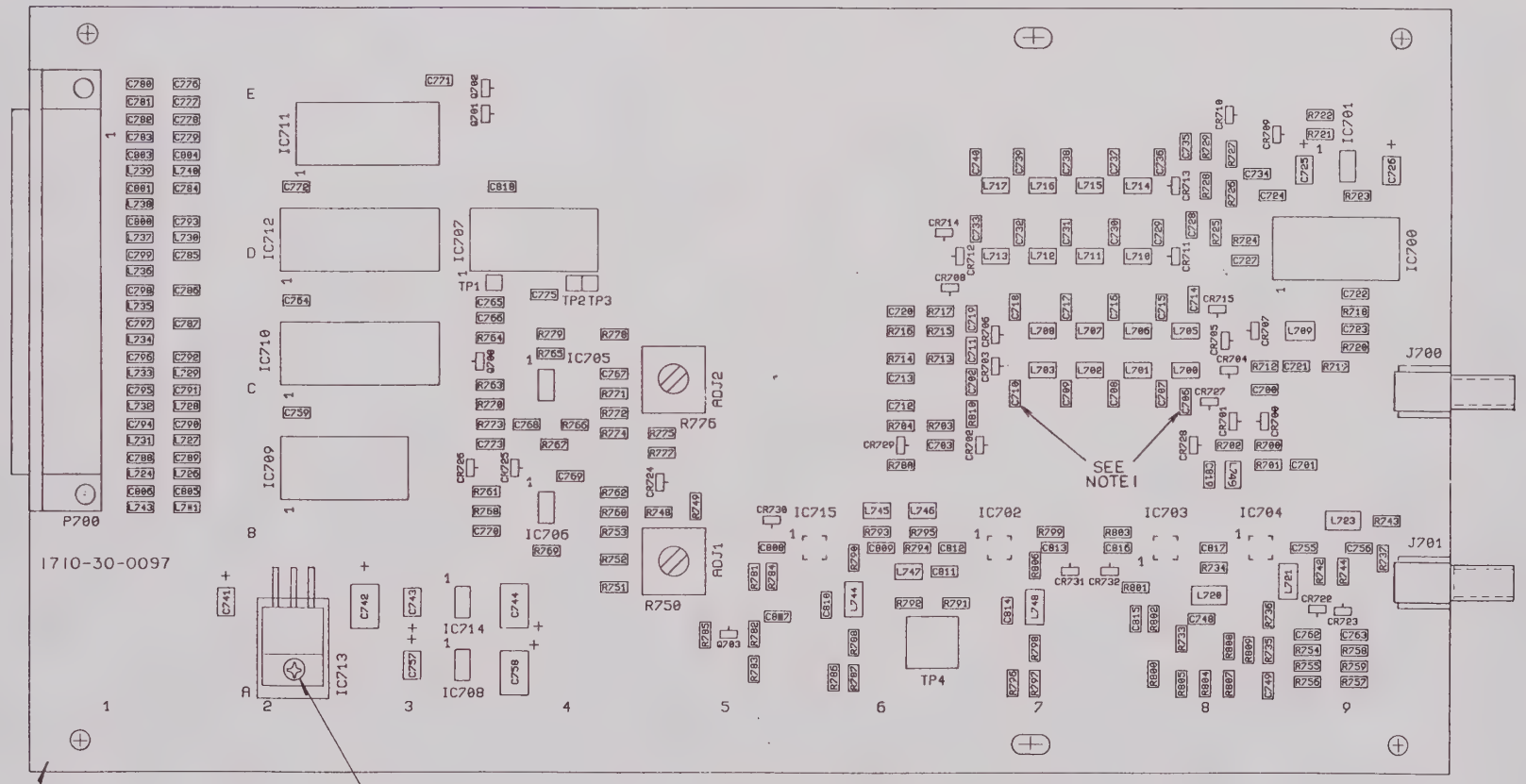
REV	PIN NO	CHANGES	DATE	BY
C	1944	SCHEM MATCH BOM'S	10/30/90	HD
B	1692	P.C. BOARD IMPROVEMENTS	7/5/89	
A	1633	VALUE CHANGES	4/5/89	

REVISIONS

NEXT ASSY	USED ON
1110-00-2314	2407 PC ASSY
1219-00-0736	HYBRID 2407

WAVETEK			
TITLE	AM/DIVIDER BD SCH.		REV C
DRAWN	6-12-88	CHKD	APP
SCALE	NONE	FILE NAME	WAVEAM.SCH
SHT 1 OF 1		FILE NO.	0014-30-0426

REVISIONS				
REV	DESCRIPTION	BY	DATE	P/N
A				
B	PERFORMANCE IMPROVE		1/89	4692
C	Release to Production	M	4/89	4751
D	ADDED ITEM 5 COMPOUND AND NOTE 1 for C706 & C710	M	9/89	4944



SMT/LEADED COMPONENT SIDE
SIDE 1

DETAIL "A"
2x SIZE

NOTES

1) COMPONENTS C706 & C710 ARE SHOWN ON PARTS LAYOUT AND SCHEMATIC BUT ARE NOT INSTALLED AT THIS TIME ON BOM'S.

REF B.O.M. 1219-00-0736
1110-00-2314

	2407
1110-00-2314	PCB ASSY 2407
1219-00-0736	HYBRID PT
NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ARE:
FRACTIONS DECIMALS ANGLES
± N/A .XX ± N/A ±
.XXX ±

MATERIAL: SEE BOMS LISTED
FINISH: NA

CONTRACT NO.

APPROVALS	DATE
DRAWN Fields	8/89
CHECKED E Kohl	9/13/89

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AM/DIVIDER ASSY DWG, SIDE 1

SIZE	CODE IDENT NO.	DRAWING NO.	REV
D	34280	0012-30-0120	D

SCALE 2:1 | DO NOT SCALE DRAWING | SHEET 1 OF 1

9-24

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REV	ECN	BY	DATE	APP
	B PROTOTYPE	ABEL	4/89	
4756	A RELEASED	ABEL	9/89	

J800 RF IN
J801 LO IN
J802 AUX OUT
J804
MSA8384 IC801
MSA8384 IC802
MSA8384 IC803
MSA8384 IC804
SCM-1NL MX800
IC802 NE5205
IC803 VDN6118A
IC804 78L05A
IC805 7815
IC806 79M15
IC807 74HC574
IC808 74HC574
IC901 74HC541
IC902 74HC138
Q801 BSR17A
Q802 MMBFJ310
Q803 BSR17A
Q804 3N201
Q805 BSR17A
Q806 BSR17A
Q807 BSR17A
Q808 BSR17A
Q809 BSR17A
Q810 MMBFJ310
CR801 4P277
CR802 4P277
CR803 4P277
CR804 4P277
CR805 4P277
CR806 4P277
CR807 4P277
CR808 4P277
CR809 4P277
CR810 4P277
CR811 4P277
CR812 4P277

TO SHEET 2 GAIN CONTROL
AA TO SHEET 2
BB TO SHEET 2
GAIN CONTROL
+15V
-15V
+5V
-5V
+8V
-8V
+18V
-18V

TO SHEET 2 DET TEST
TO SHEET 2 PIN TEST
LEVEL REF SHEET 2
TPX SHEET 2
UNLEVEL OUT SHEET 2
DIG GND
LEV RETURN
TPX RETURN
L907 - L909
L910 - L917
L918 - L919
L920 - L926
C916 - C928
C922 - C929
C931 - C937
C938 - C951
C953 - C955
C956 - C960
RFD7 RFD6 RFD5 RFD4 RFD3 RFD2 RFD1 RFD0
/SEL4 RFA4 RFA2 RFA1 RFA0
GND

† NOTE: CONNECT DIG GND TO CHASSIS GND ONLY AT PIN 7 OF J804

• NOMINAL VALUES SHOWN; MAY BE ADJUSTED DURING CALIBRATION

LAST DESIG. USED

C869	Q888
C961	Q928
R998	CR825
L819	
L926	

NEXT ASSEMBLY	USED ON

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B ABEL	DATE 14:29 19 SEP 1989	WAVETEK
MATERIAL	PROJENGR M CETTER		TITLE MFG / ENGR CHECK SET
	RELEASE APPROV S MUSSMANN		SCHEMATIC OUTPUT BD.
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± ANGLES XX ± ±		
	DO NOT SCALE DWG SCALE N/A	MODEL NO 2410	DWG NO 0014-30-0438 REV A
	M.89012.RA /V8 FAB	CODE IDENT 34280	C11A SHEET 1 OF 2

0014-30-0438 A

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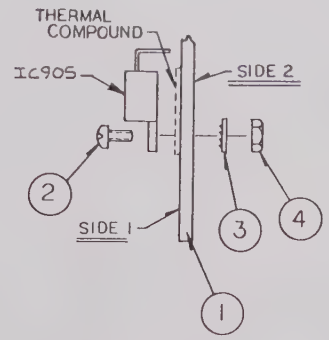
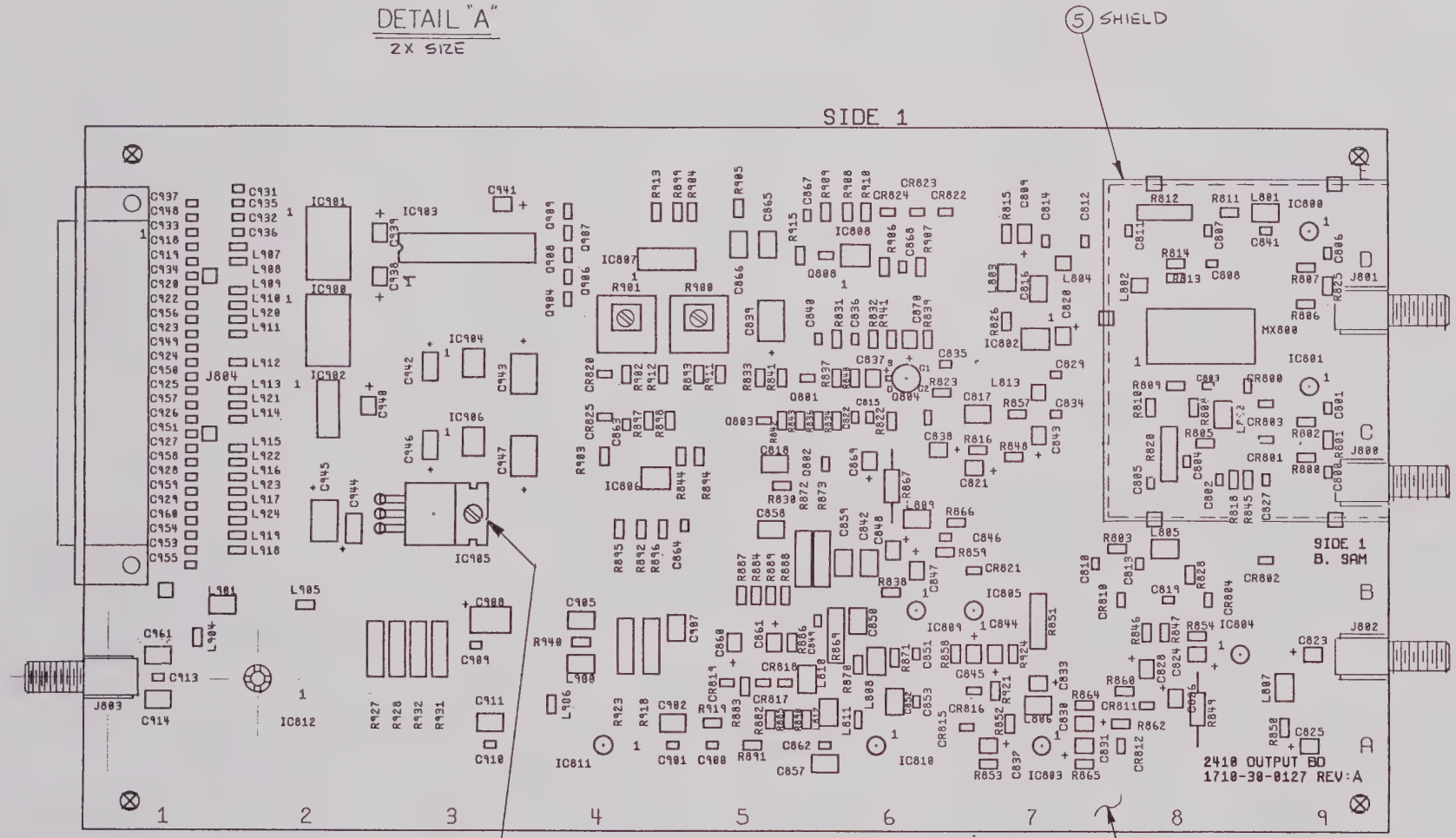
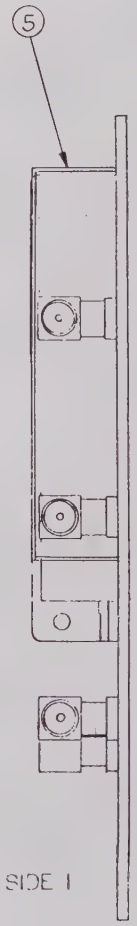
REV	ECN	BY	DATE	APP

PIN NO	REV	CHANGE	BY	DATE	APP
4756	A	RELEASED TO PROD.	EK	9/9/89	



DETAIL "A"
2X SIZE





SMT/ LEADED SIDE
COMPONENT SIDE
SIDE 1

SEE DETAIL "A" (2)

(1)

REF BOM 1219-00-0764 HYBRID PARTS
REF BOM 1110-00-2329 PC ASSY PARTS

1110-00-2329	2410 PC ASSEM
1219-00-0764	2410 HYBRID
NEXT ASSEMBLY	USED ON

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN E KOHL	DATE 10/9/89
MATERIAL SEE BOM LISTED	PROJ ENGR	
	RELEASE APPROV	
FINISH WAVETEK PROCESS NA	TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX ± NA ANGLES XX ± NA	
	DO NOT SCALE DWG	
	SCALE 2:1	
	TM.89012.RA 'V8.FAB	

WAVETEK

TITLE MFG / ENGR CHECK SET
ASSEMBLY DWG SIDE 1
OUTPUT BD

MODEL NO.	DWG NO.	REV
2410 -	0012-30-0163	A

CODE IDENT 34280 | C2A | SHEET 1 OF 1

0012-30-0163 A

9-26

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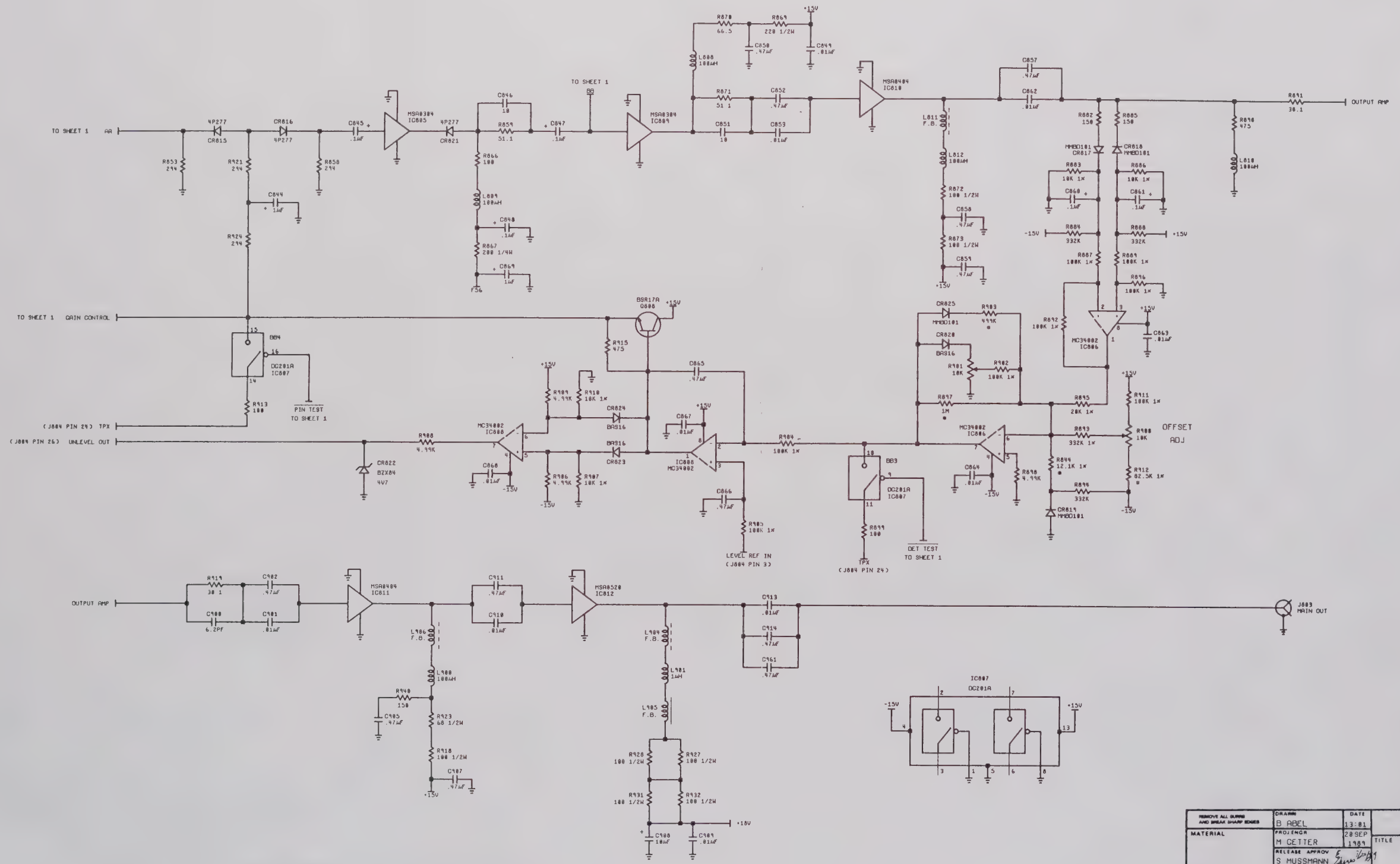
REV	ECN	BY	DATE	APP
B	PROTOTYPE	ABEL	4/89	
A	RELEASED	ABEL	9/89	



* NOMINAL VALUES SHOWN; MAY BE ADJUSTED DURING CALIBRATION

NEXT ASSEMBLY	USED ON

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B ABEL	DATE 13:01 28SEP 1989
MATERIAL	PROJ ENGR M GETTER	
	RELEASE APPROV S MUSSMANN	
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX± ANGLES ± XX±	
	DO NOT SCALE DWG	
	SCALE N/A	
	M.8912.RA /V8 FAB	

WAVETEK

TITLE MFC / ENGR CHECK SET

SCHEMATIC OUTPUT BD.

MODEL NO	DWG NO	REV
2410	0014-30-0438	A

CODE IDENT 34280 C12A SHEET 2 OF 2

0014-30-0438 A

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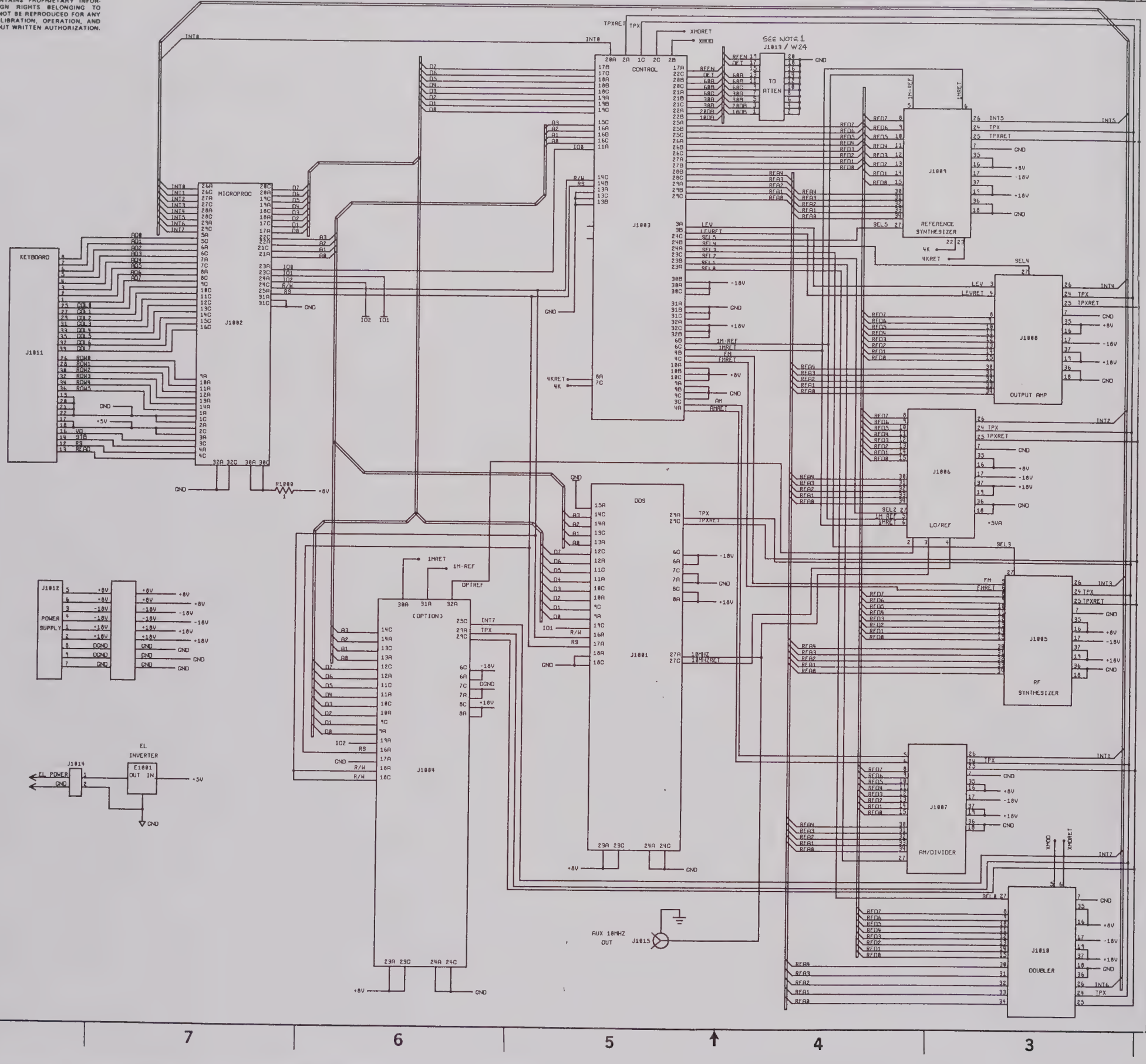
REV	ECN	BY	DATE	APP
B	PROTOTYPE	RK	7/98	
PIN# 4938	A RELEASE TO PROD	RK	7/98	
PIN# 4950	B CHANGED R1888 VALUE	RK	10/98	



NOTES:
1) J1013 20 PIN HEADER FOR 2410A ONLY, AND W24 RIBBON CABLE ASSY FOR 2410AR ONLY.

1110-00-2361	2410AR
1110-00-2339	2410A / 2405A
NEXT ASSEMBLY	USED ON

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN R KORRECK	DATE 12:46 12 OCT 1998
MATERIAL N/A	PROJ ENGR E GAINES	
	RELEASE APPROV	
FINISH WAVETEK PROCESS N/A	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX± ANGLES ± XX±	
	DO NOT SCALE DWG	
	SCALE N/A	
	TM.9888.RB /V1.FAB	

WAVETEK
MFG / ENGR SHEET SET
TITLE
SCHEMATIC
MOTHER BD.

MODEL NO	DWG NO	REV
2410A	0014-30-0441	B
CODE IDENT 34280	SIZE A	SHEET 1 OF 1

0014-30-0441

9-28

REVISIONS				
REV	DESCRIPTION	BY	DATE	PIB
A	Released to Prod	EG	9/90	4938

J1012 1

J1001 C B A 1

J1005 1

J1010 1

<<WAVE>>

J1007 1

J1008 1

V

J1002 C B A 1

R1000

J1003 C B A 1

J1013 1

J1004 C B A 1

J1006 1

J1009 1

1 5 (D CONN 9G PIN) 1 6 3 - 8 PLC'S

2

J1011 1

J1015

J1014 1

E1001

4

1 6 3 5

R1000 TO BE MOUNTED ON BACKSIDE SIDE 2.

J1013 TO BE MOUNTED ON BACKSIDE SIDE 2.

2 6 1 (D CONN 37-POS) - 12 PLCS

2410A MOTHER BD
1710-30-0165 REV B SIDE 1

COMPONENT SIDE
SIDE 1

1110-00-2339	PC ASSY		
NEXT ASSY	USED ON		
APPLICATION			

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ARE:
FRACTIONS DECIMALS ANGLES
± XX ± ±
XXX ±

MATERIAL: SEE BOM LISTED
FINISH: N/A

CONTRACT NO

APPROVALS	DATE
DRAWN Fields	9/90
CHECKED E GAINES	

2410 A

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PARTS LAYOUT
MOTHER BD

SIZE	CODE IDENT NO	DRAWING NO	REV
D	34280	0012-30-0176	A

SCALE 2X | DO NOT SCALE DRAWING | SHEET 1 OF 1

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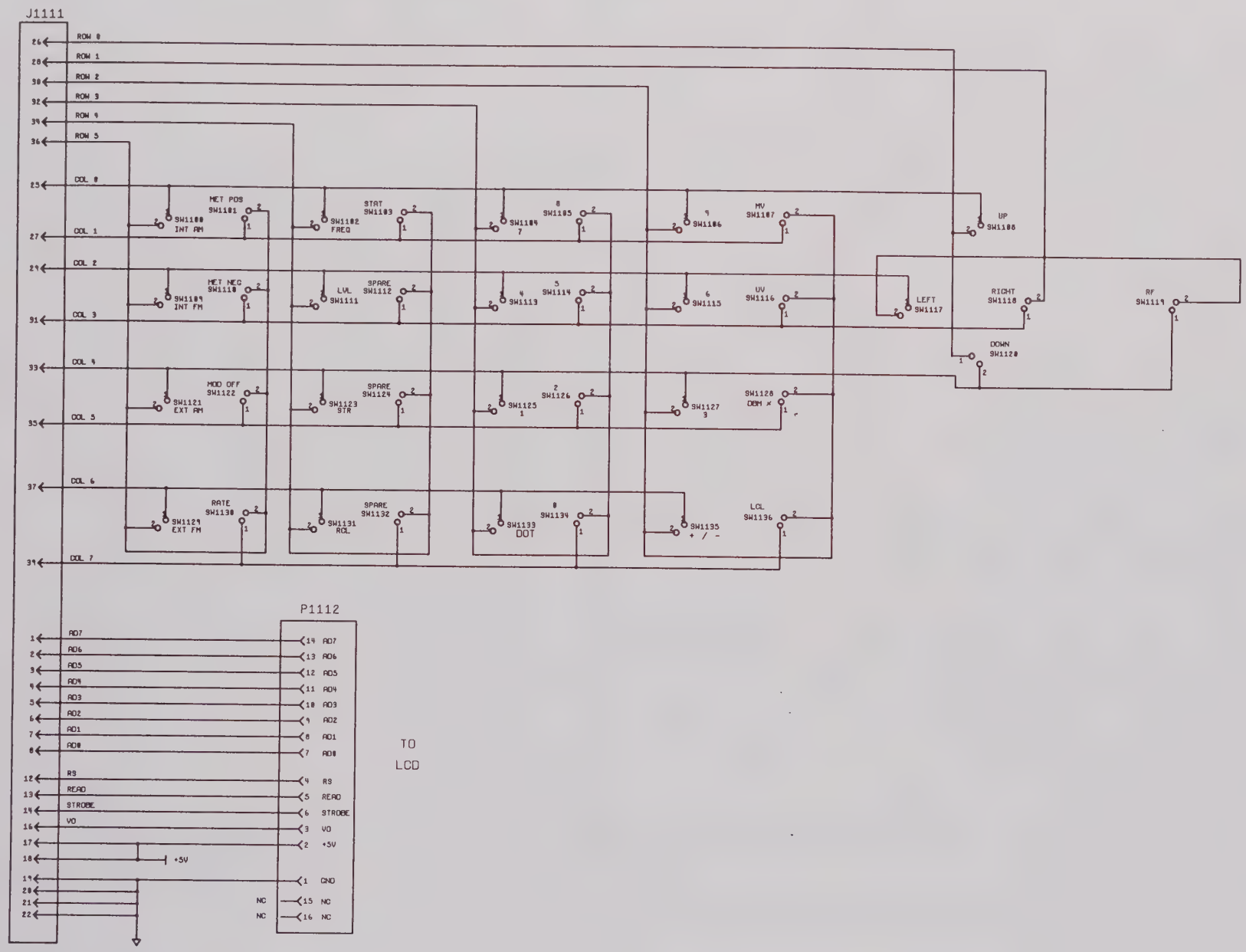
PIN NO.	REV	ECN	BY	DATE	APP
4731	A	RELEASE			



NOTE: UNLESS OTHERWISE SPECIFIED,

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN P FIELDER	DATE 12:44 1 JUN 1988	WAVETEK
MATERIAL	PROJ ENGR. E CHAN		TITLE MFG / ENGR CHECK SET
	RELEASE APPROV. S MUSSMANN		SCHEMATIC KEYBOARD
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ANGLES XX		
	DO NOT SCALE DWG. SCALE NONE	MODEL NO. 2407	DWG NO. 0014-30-0425 REV A
	TM.88883.R2 /U99.FAB	CODE IDENT 34280	C11A SHEET 1 OF 1

PM.0014-30-0425 REV A

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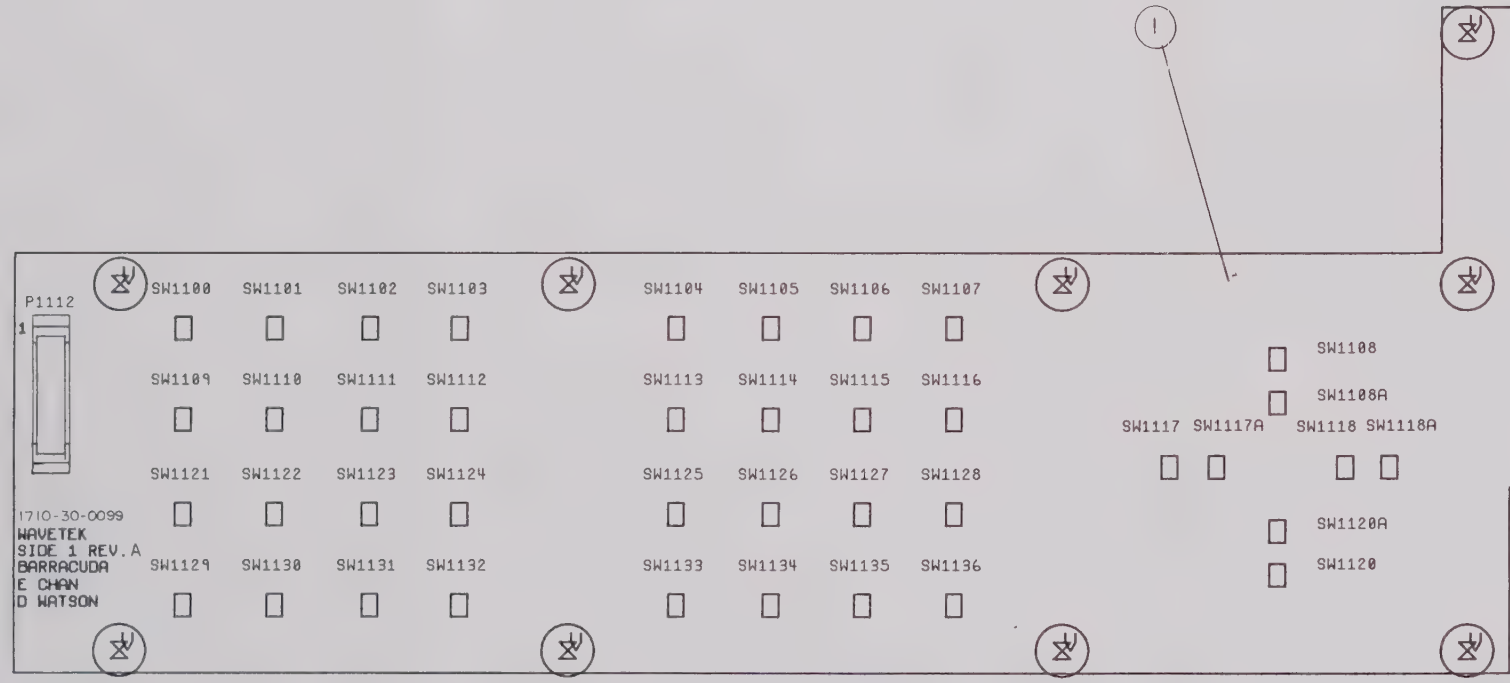
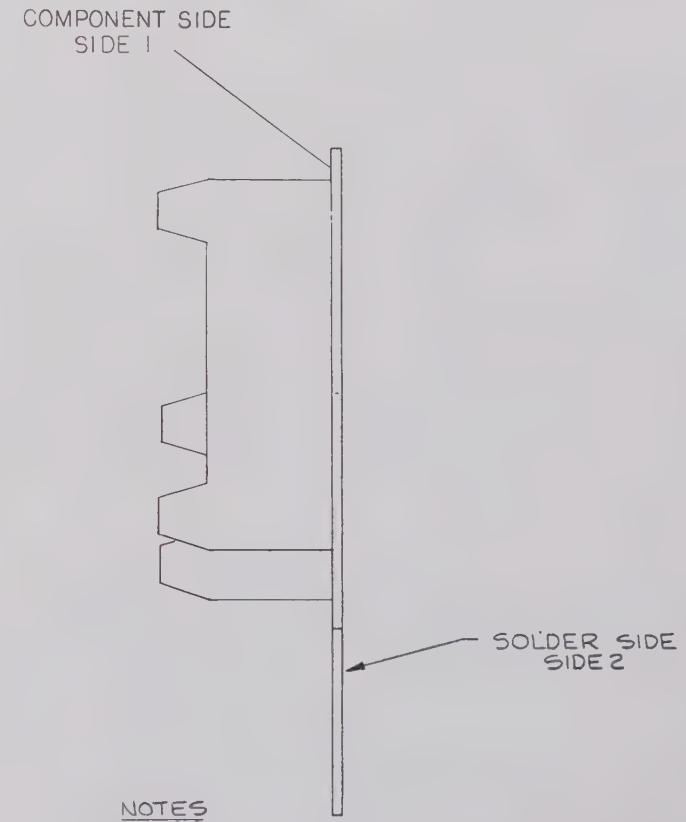
PIN NO.	REV	ECN	BY	DATE	APP
4731	A	RELEASE	DG.	9 89	
4922	B	ADDED SIDE VIEW B.D. NUMBER AND ECP PER	RJ	1-90	EK



COMPONENT SIDE
SIDE 1



NOTES
1) REFERENCE DESIGNATORS. (EXAMPLE: SW1106 SW1113, SW1119 ETC.) ARE NOT ACTUAL SWITCHES MOUNTED TO THIS BOARD ITEM 1. THEY ARE OF A CARBON MATERIAL FOR THE KEYPAD.

REF BOM #1216-00-0350

NOTE UNLESS OTHERWISE SPECIFIED

1216-00-0350	KEYBD ASSY, 2407		
NEXT ASSY	WHERE USED		

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B ABEL	DATE 12:43 1 JUN 1988	WAVETEK
MATERIAL SEE BOM LISTED	PROJENGR. E CHAN		TITLE MFG / ENGR CHECK SET TOP ASSEMBLY DWG KEYBOARD
FINISH WAVETEK PROCESS NA	RELEASE APPROV S MUSSMANN	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX NA ANGLES NA XX	
	DO NOT SCALE DWG. SCALE 2-1	TM.88883.R2 /U99.FAB	MODEL NO BARRACUDA / DWG NO 0012-30-0119 / REV B
		CODE IDENT 34280	CAD SHEET 1 OF 1

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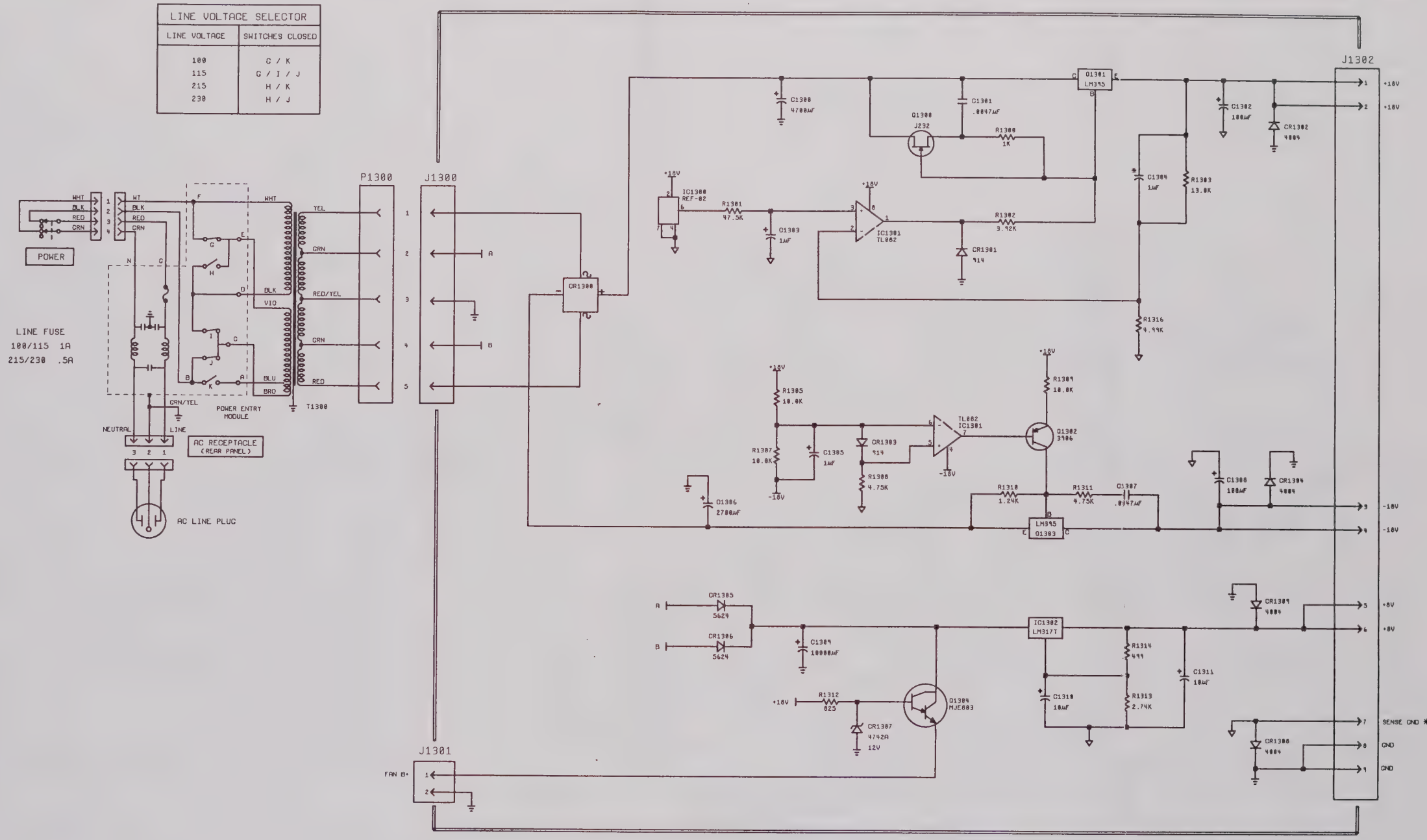
HISTORY	REV	ECN	BY	DATE	APP
PIN4731	A	RELEASE	DW	5/89	
4944	B	ADD WHERE USED	RK	10/90	RK

LINE VOLTAGE SELECTOR	
LINE VOLTAGE	SWITCHES CLOSED
100	G / K
115	G / I / J
215	H / K
230	H / J



* SENSE GND SHOULD BE CONNECTED TO CIRCUIT GND AT LOAD FOR PROPER OPERATION

1110-00-2370	PC ASSY P/S 24XXA
1110-00-2312	PC ASSY P/S 2407
1216-00-0371	HEAT SINK ASSY 24XXA
0811-00-0019	DWG LIST 2407
1216-00-0349	HEAT SINK ASSY 2407
NEXT ASSEMBLY	USED ON

REMOVE ALL BURRS AND BREAK SHARP EDGES

MATERIAL: SEE BOM LISTED

FINISH WAVETEK PROCESS: N/A

DRAWN: P FIELDER — DATE: 13:18

PROJ ENGR: E GAINES — 2 OCT 1990

RELEASE APPROV: S MUSSMANN

TOLERANCE UNLESS OTHERWISE SPECIFIED: XXX ± N/A ANGLES ±, XX ±

DO NOT SCALE DWG

SCALE: N/A

TM.88815.RC /V24.FAB

WAVETEK

TITLE: MFG / ENGR CHECK SET

SCHEMATIC
POWER SUPPLY

MODEL NO	DWG NO	REV
BARRACUDA	0014-30-0423	B

CODE IDENT 34280 — CAGE — SHEET 1 OF 1

0014-30-0423 B

9-32

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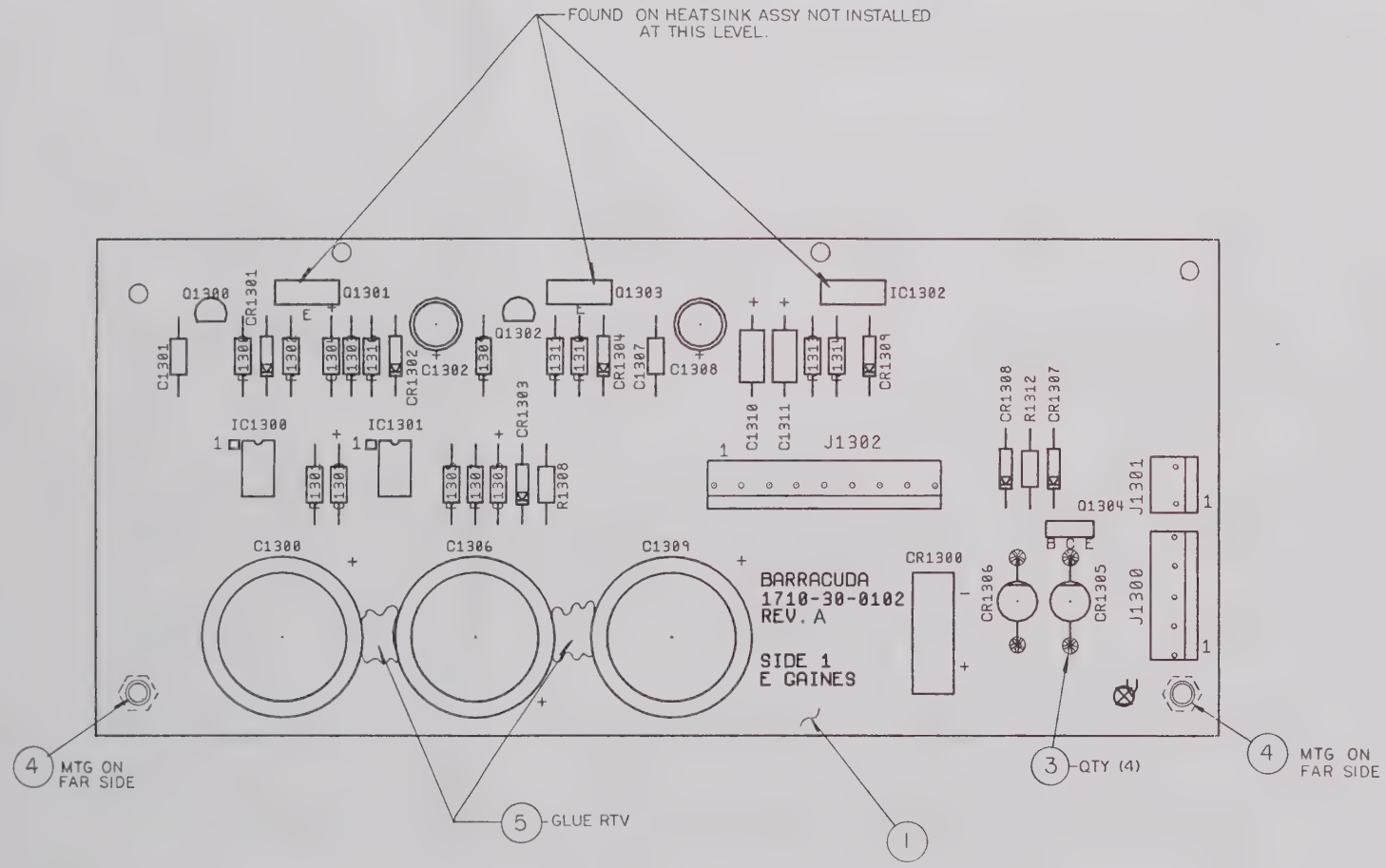
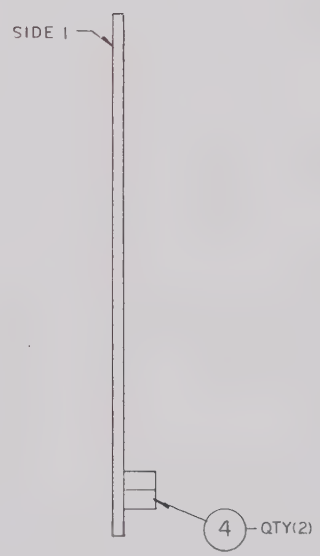
HISTORY	REV.	ECN	BY	DATE	APP
4731	A	RELEASE	EG	8-89	
4944	B	Add end view and component designators.		10/90	





REF B.O.M. 1110-00-2370 PC ASSY
1110-00-2312 PC ASSY

COMPONENT SIDE
SIDE 1

NOTE UNLESS OTHERWISE SPECIFIED

1110 00 2370	PC ASSY P/S 24XXA
1110-00-2312	PC ASSY P/S 2407
0011-00-0019	DWG LIST 2407
NEXT ASSY	USED ON

REMOVE ALL BURRS AND BREAK SHARP EDGES
MATERIAL: SEE B.O.M.'S LISTED
FINISH WAVETEK PROCESS: N/A
DRAWN: B ABEL — DATE: 09:01 2200 1988
PROJ ENGR: E GAINES
RELEASE APPROV: S MUSSMANN
TOLERANCE UNLESS OTHERWISE SPECIFIED: XXX / XX / ANGLES
DO NOT SCALE DWG.
SCALE 2:1
TM.88815.R2 /V21 FAB

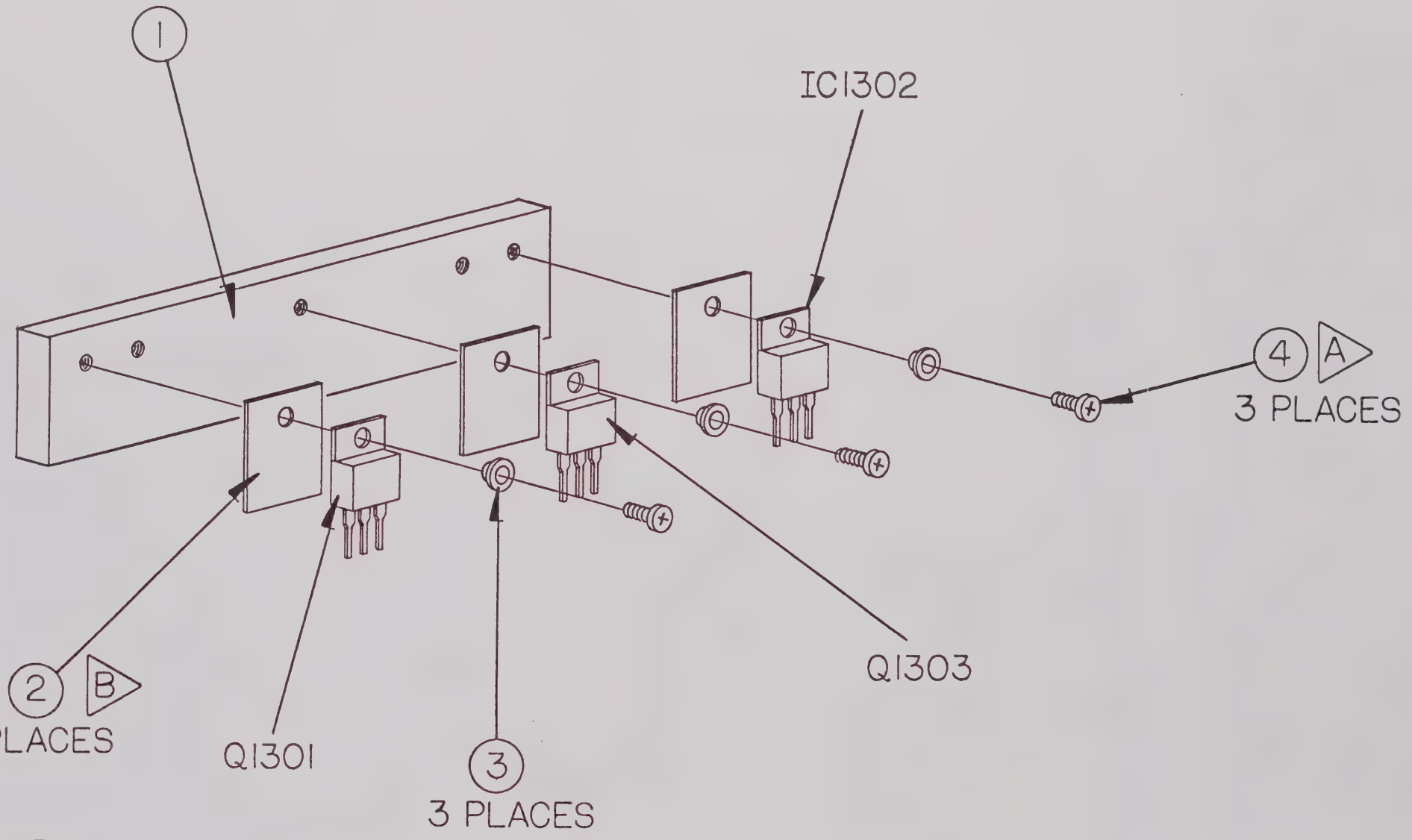
WAVETEK
TITLE: MFG / ENGR CHECK SET
TOP ASSEMBLY DWG
POWER SUPPLY

MODEL NO	DWG NO	REV
2407	0012-30-0117	B

CODE IDENT 34280 — C2A — SHEET 1 OF 1

REV B
PA 0012-30-0117

REVISIONS				
REV	DESCRIPTION	BY	DATE	PIN
A	RELEASE	DW	4-89	4731



A TORQUE TO 4.7 IN-LBS

B THERMAL COMPOUND TO BE USED BETWEEN HEATSINK AND INSULATORS AND ALSO Q1301 AND INSULATOR.

REF. BOM #1216-00-0349

1216-00-0349	2407
NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ARE:
FRACTIONS DECIMALS ANGLES
± .XX ± ±
.XXX ±

MATERIAL

FINISH

CONTRACT NO.

APPROVALS	DATE
DRAWN DJ WATSON	9-88
CHECKED	

24XX/24XXR

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HEATSINK ASSY. DRAWING

SIZE	CODE IDENT NO.	DRAWING NO.	REV.
B	34280	0012-10-0133	A

SCALE NTS | DO NOT SCALE DRAWING | SHEET 1 OF 1

TELEDYNE POST N24638

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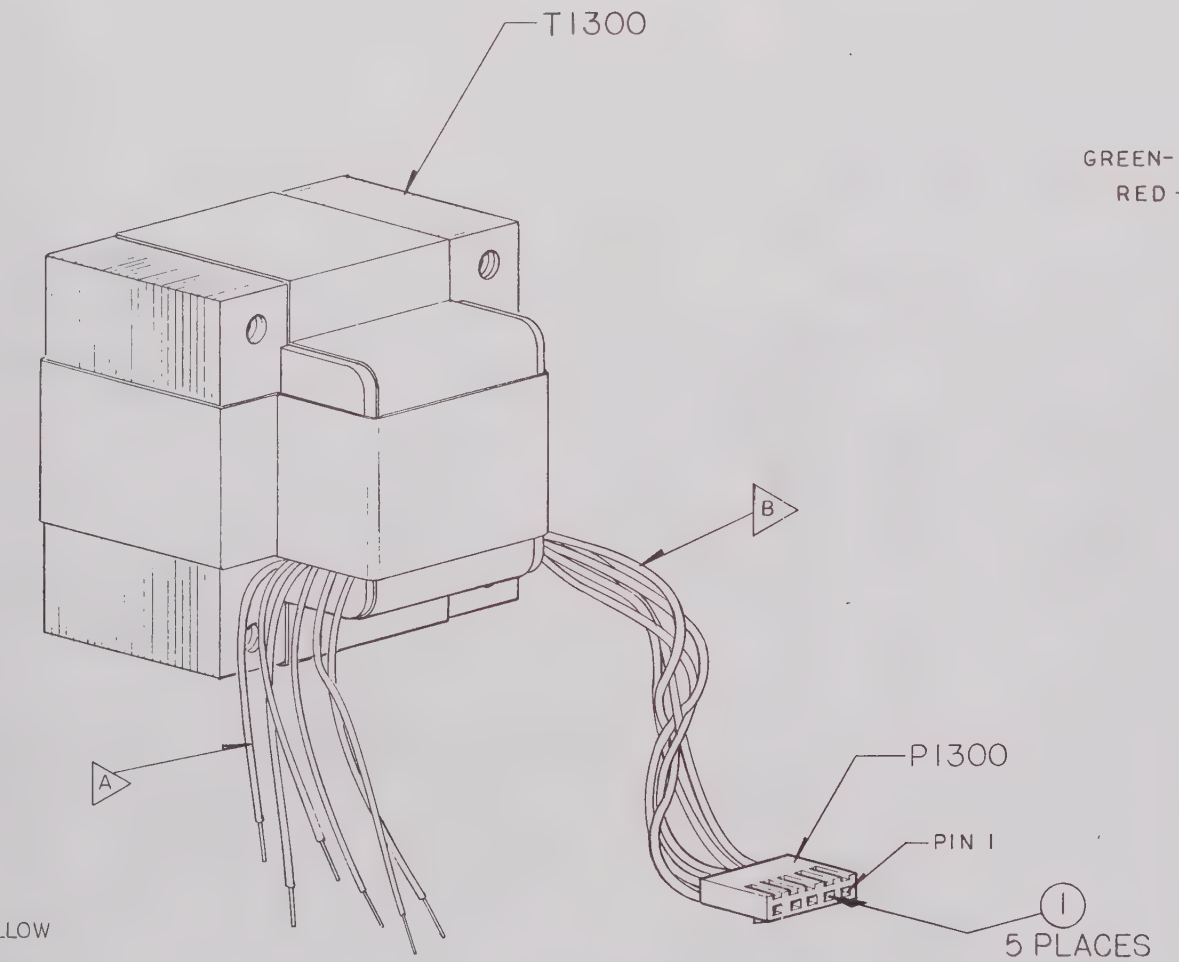
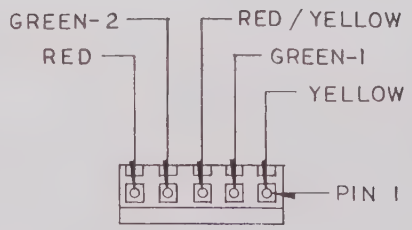
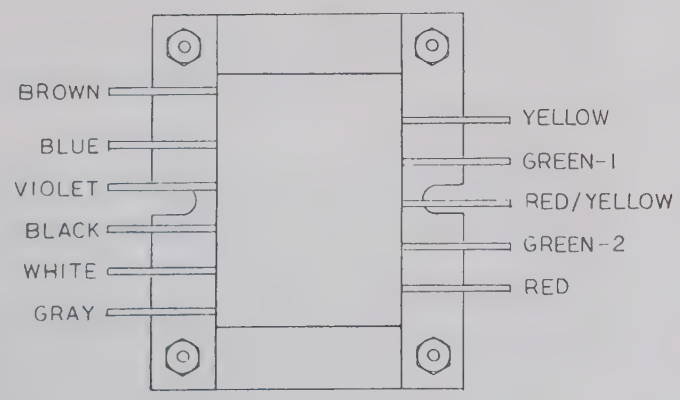
PIN #	REV	ECN	BY	DATE	APP
4731	A	RELEASE	DW	4-89	

(A) LEAD LENGTH IS 6" ± 1/2"
STRIP ENDS 3/8"

(B) LEAD LENGTH IS 6" ± 1/2"
STRIP ENDS 1/8"







REFERENCE B.O.M. 1219-00-0731

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN L Fields	DATE 9/88	WAVETEK
MATERIAL N/A	PROJ ENGR		TITLE TRANSFORMER ASSEMBLY
	RELEASE APPROV Sara H. Hustrom 2/3/89		
FINISH WAVETEK PROCESS N/A	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± ANGLES XX ± ±		
	DO NOT SCALE DWG	MODEL NO 2407	DWG NO 0012-20-0100 REV A
	SCALE NONE	CODE IDENT 34280	SHEET 1 OF 1

0012-20-0100 REV A

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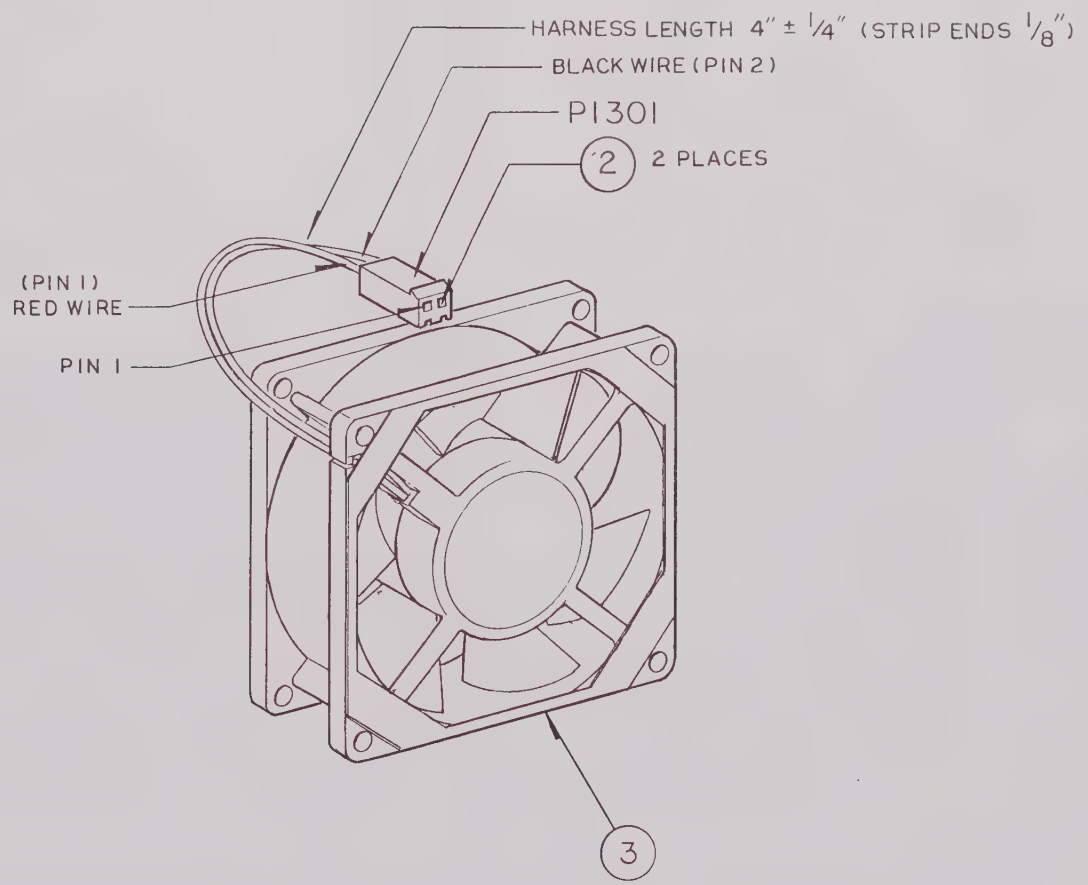
PIN #	REV	ECN	BY	DATE	APP
4731	A	RELEASE	DW	4-89	



REF: B.O.M. # 1219-00-0732

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN L Fulda 9/88	WAVETEK	
MATERIAL N/A	PROJ ENGR	TITLE FAN ASSY. DRWG	
	RELEASE APPROV Sara H Huttmann 7/31/89		
FINISH WAVETEK PROCESS N/A	TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX ± N/A ANGLES ± .XX ±		
	DO NOT SCALE DWG	MODEL NO. 2407	DWG NO. 0012-20-0101 REV A
	SCALE NONE	CODE IDENT 34280	SHEET 1 OF 1

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PIN NO	REV	ECN	BY	DATE	APP
*4938	A	PRODUCTION	RK	7/98	EG
4950	B	ADDED R1575, R1576, Q1589	RK	10/98	EG

DIGITAL INTERFACE

DIVIDE BY N

UNLOCK DETECTOR

LOOP FILTER

PHASE DETECTOR

32MHZ VCO

DIVIDE BY 32

MIXER

SPARES

CONNECTED AT P1501 ONLY

NOTE:
1. ⊛ SYMBOL DENOTES STAR VALUE TO BE DETERMINED BY MFG TECH WHEN REQUIRED FOR CALIBRATION

1110-00-2338	2410A
NEXT ASSEMBLY	USED ON

REMOVE ALL BURRS AND BREAK SHARP EDGES
MATERIAL: NA
FINISH WAVETEK PROCESS: NA
DRAWN: R KORRECK — DATE: 13-57
PROJENGR: E GAINES — 22OCT 1998
RELEASE APPROV
TOLERANCE UNLESS OTHERWISE SPECIFIED: XX ±N/A, ANGLES ± N/A
DO NOT SCALE DWG
SCALE: N/A
TM: 9803.RB /V1 FAB

WAVETEK
MFG / ENGR CHECK SCP
TITLE: SCHEMATIC REF/SYNTHESIZER

MODEL NO	DWG NO	REV
2410A	0014-30-0436	B

CODE IDENT 34280 — SIZE A — SHEET 1 OF 1

0014-30-0436 B

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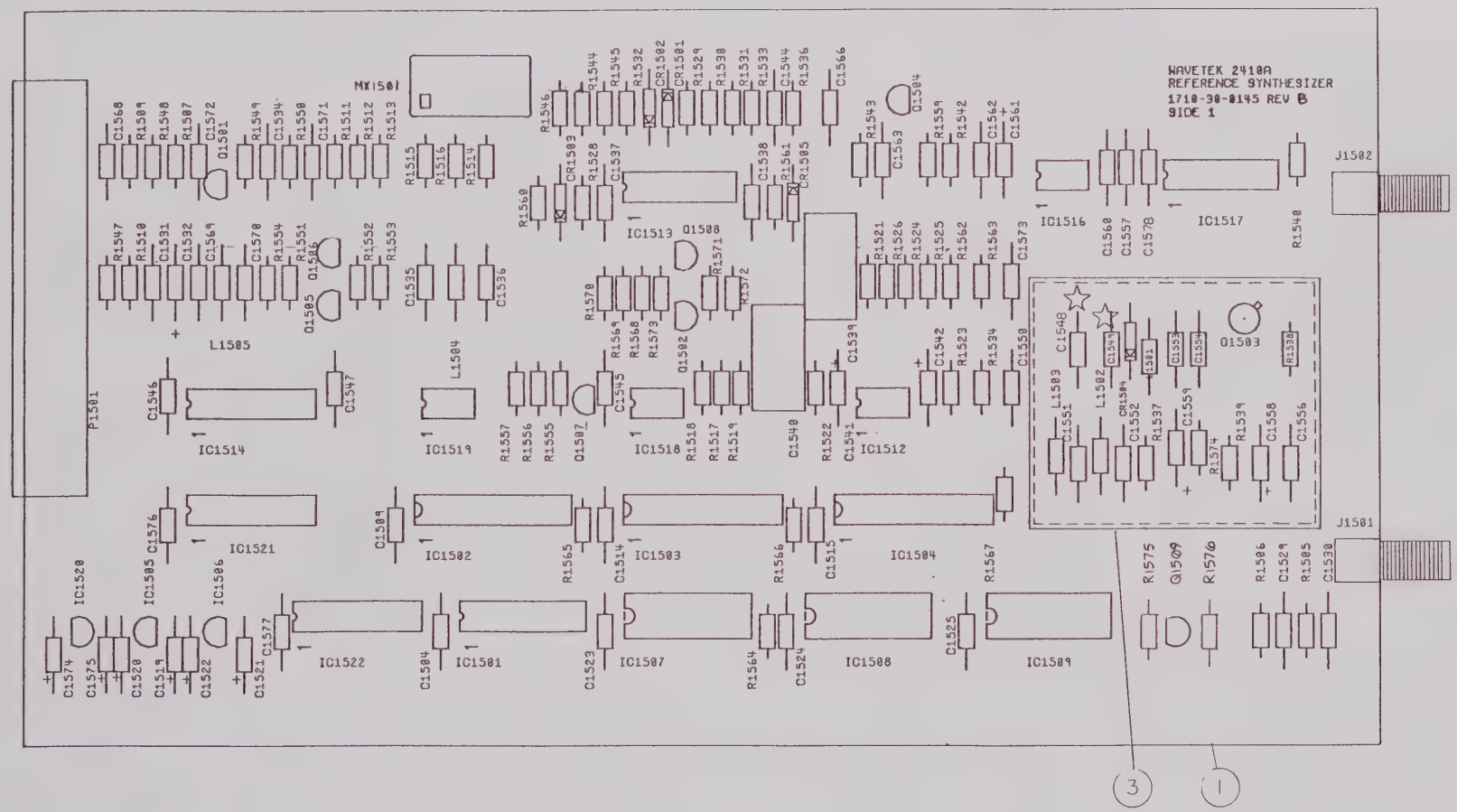
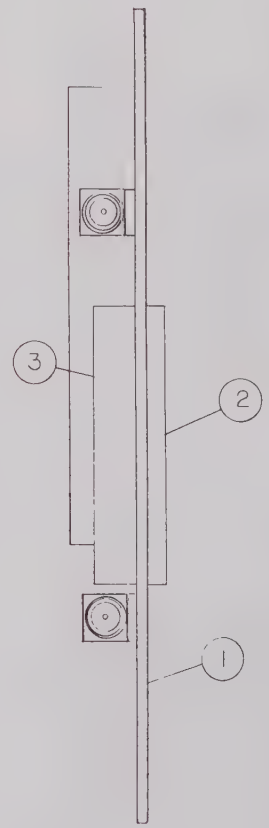
PIN	REV	ECN	BY	DATE	APP
41138	A	Release to Prod	EG	9/90	
41150	B	ADDED R1575 R1576 AND Q1508, ADDED LEGEND C1578 C1548	EK	11/16/90	

SIDE 1





NOTES:
1) ☆ SYMBOL DENOTES STAR VALUE TO BE DETERMINED BY MFG. TECH. WHEN REQUIRED FOR CALIBRATION.

0012-30-0157 B

1110-00-2338	PC ASSY REF SYN.
NEXT ASSY	WHERE USED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN J. Wells	DATE 9/90	WAVETEK
MATERIAL SEE B.O.M'S LISTED	PROJENGR E. GAINES	1998	TITLE MFG / ENGR CHECK SET: PARTS LAYOUT, SIDE 1, REF SYNTHESIZER
	RELEASE APPROV		
FINISH WAVETEK PROCESS N/A	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX± N/A ANGLES XX± ±		
	DO NOT SCALE DWG		MODEL NO 2410A / DWG NO 0012-30-0157 / REV B
	SCALE 2:1		CODE IDENT 34280 / SIZE D / SHEET 1 OF 1
	TM.90803.RA /V1.FAB		

9-38

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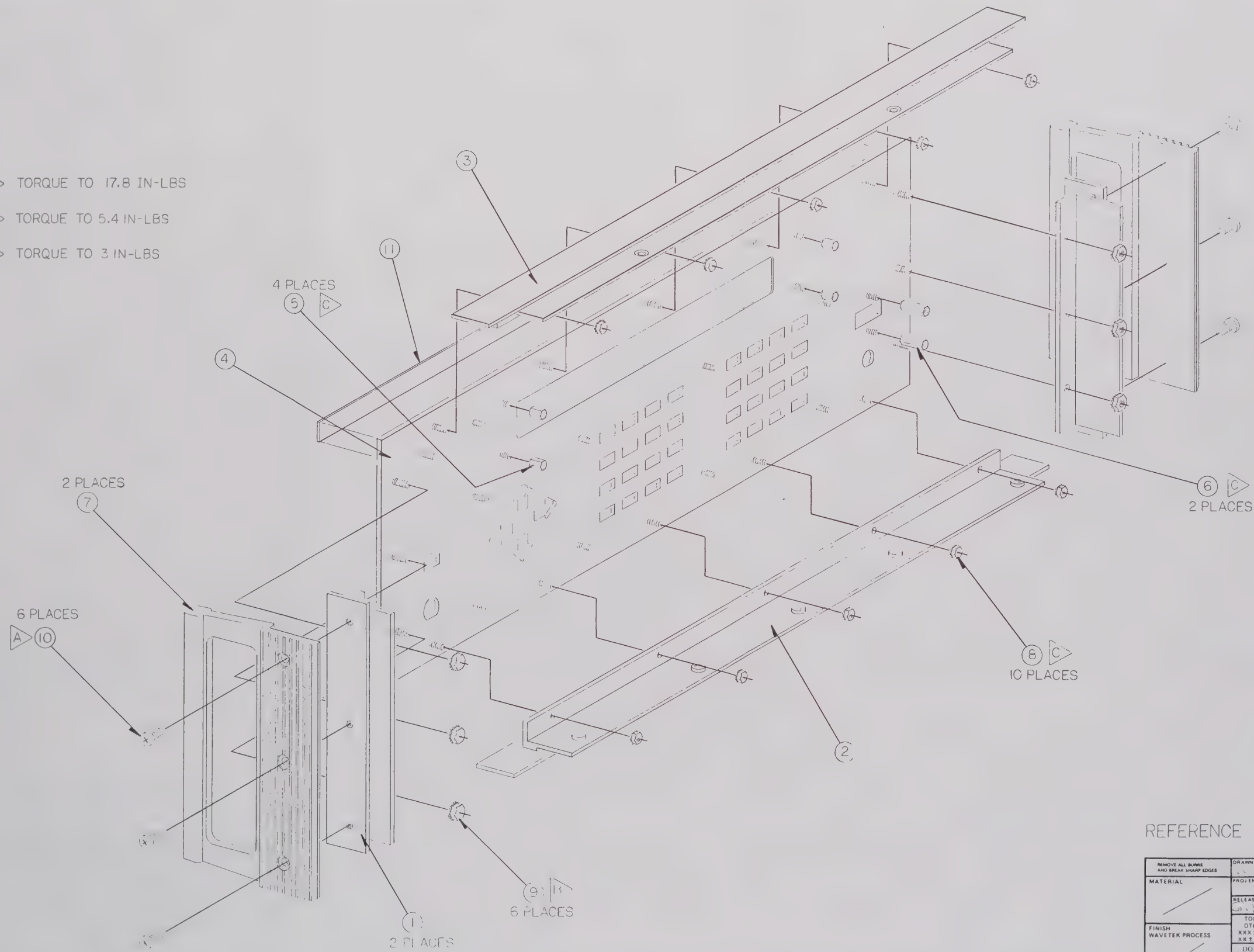
PIN ☆	REV	ECN	BY	DATE	APP
[illegible]	A	ADD VALVE [illegible]	[illegible]	3-87	[illegible]
4731	B	RELEASE	DW	4-89	
4758	C	[illegible]	[illegible]		[illegible]

A TORQUE TO 17.8 IN-LBS

B TORQUE TO 5.4 IN-LBS

C TORQUE TO 3 IN-LBS



1216-00-0364 (2410)
1216-00-0352 (2405)

REFERENCE BOM ☆1216-00-0351 (2407)

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN [illegible] DATE 3-87	WAVETEK
MATERIAL	PROJ ENGR	TITLE F.P. MECH. —ASSY DWG—
	RELEASE APPROV [illegible]	
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX± ANGLES XX± ±	
	DO NOT SCALE DWG	MODEL NO [illegible] DWG NO 0012 30 0113 REV C
	SCALE FULL	CODE IDENT 34280 SHEET 1 OF 1

0012-30-0113 REV C

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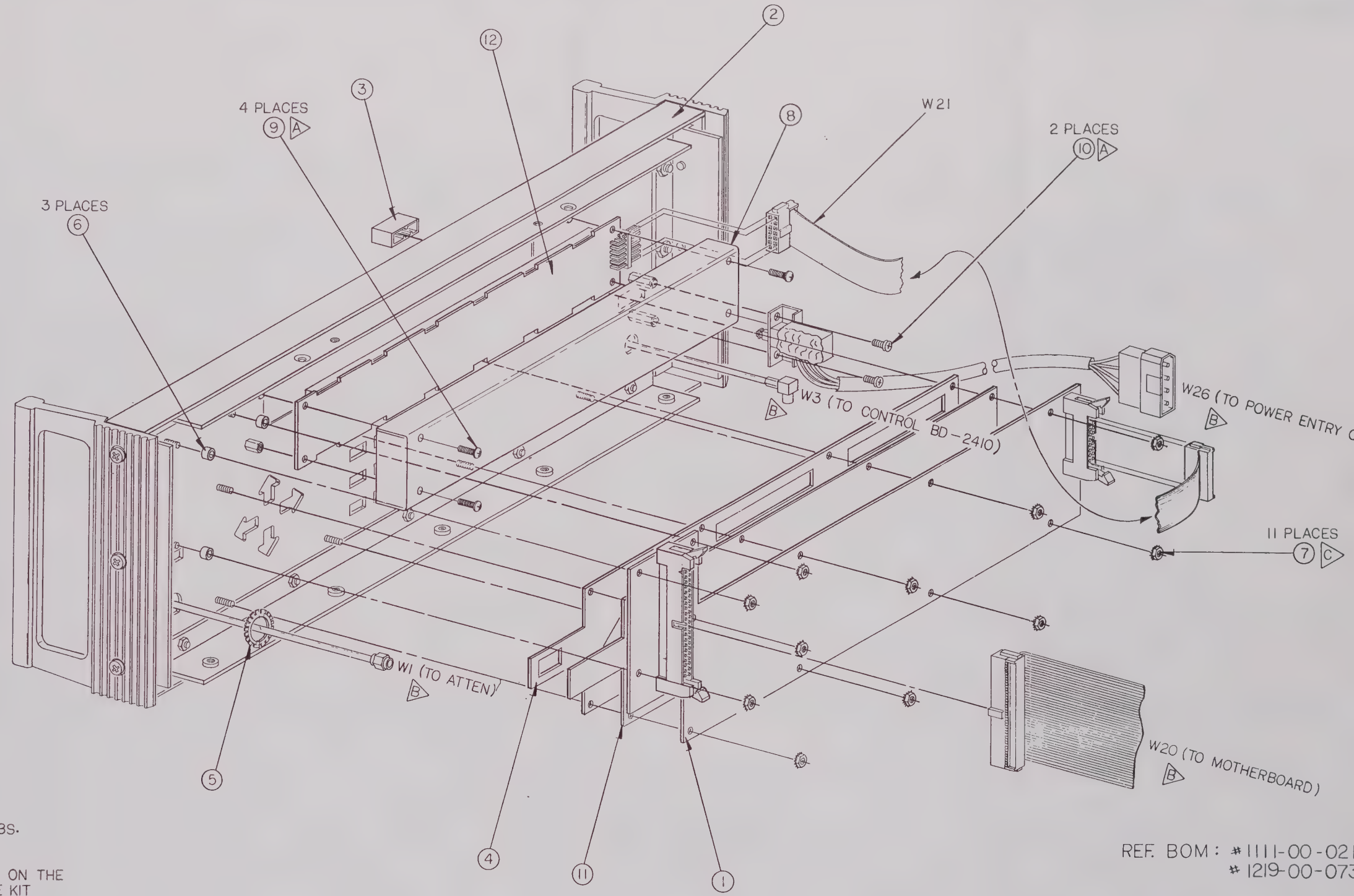
PIN #	REV	ECN	BY	DATE	APP
4756	A	RELEASE	DW	9-89	



A TORQUE TO 4.7 IN-LBS.

B THESE PARTS APPEAR ON THE FRONT PANEL CABLE KIT BOM #1219-00-0734
ITEM 13 ON B.O.M. 1111-00-0217

C TORQUE TO 3 IN-LBS.

REF. BOM: #1111-00-0217
#1219-00-0734

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN DS Watson	DATE 9-88	WAVETEK
MATERIAL	PROJ ENGR EJ	7/89	TITLE: FRONT PANEL —ASSY DWG—
	RELEASE APPROV 2-3-89 Sara H. Huetmann		
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX± ANGLES XX± ±		
	DO NOT SCALE DWG	MODEL NO 2410	DWG NO 0012-30-0164 REV A
	SCALE NTS	CODE IDENT 34280	SHEET 1 OF 1

REV 0012-30-0164

9-40

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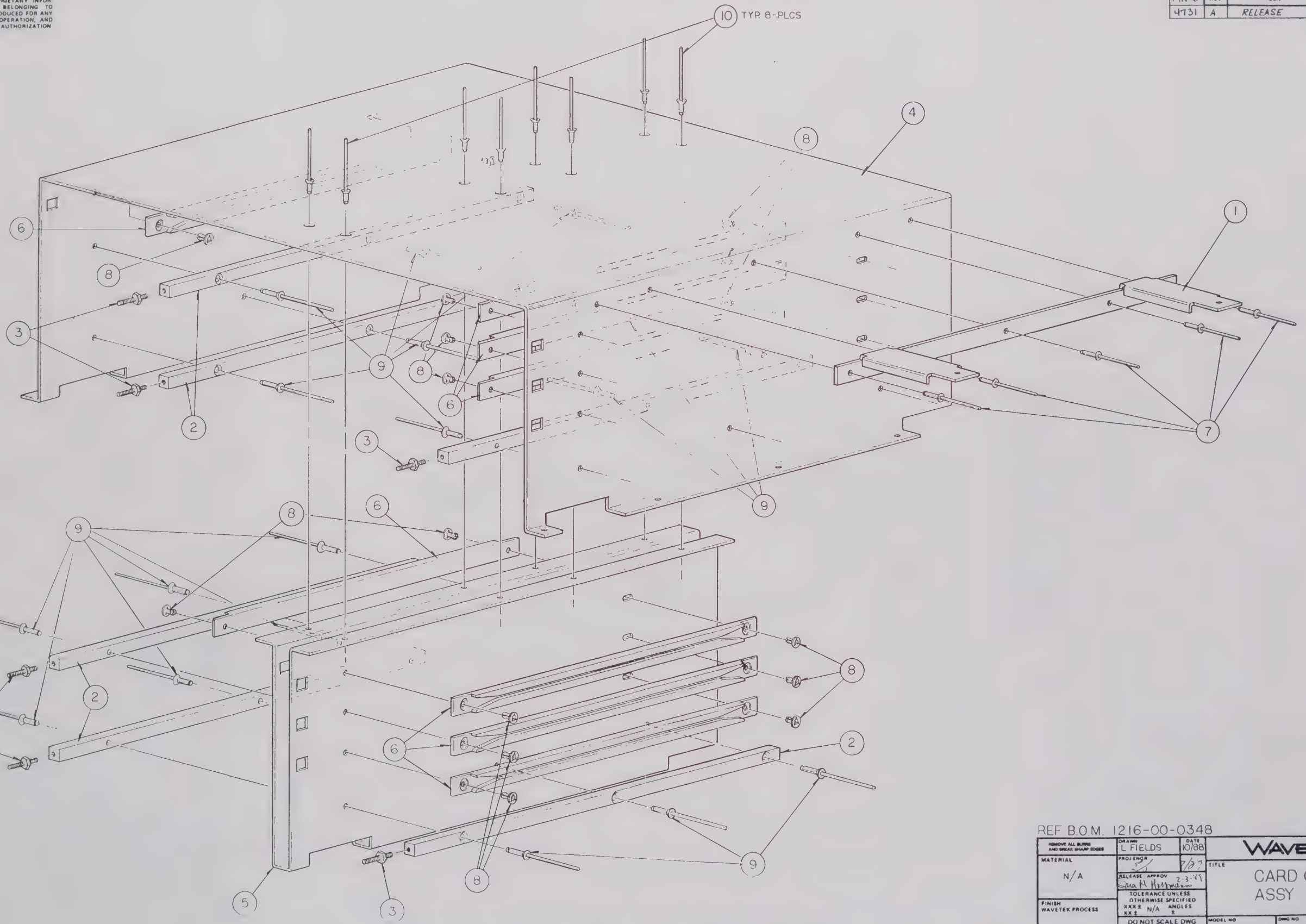
PIN #	REV	ECN	BY	DATE	APP
4731	A	RELEASE	DW	4-89	

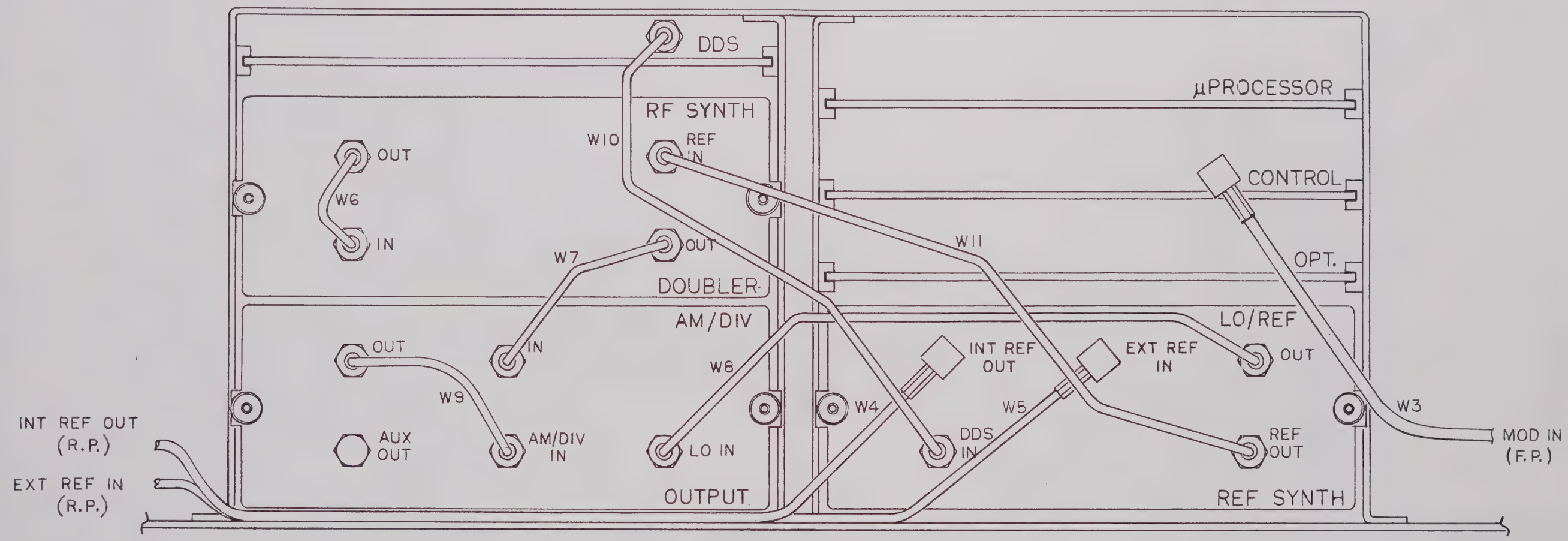


REF B.O.M. 1216-00-0348

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN L FIELDS	DATE 10/88	WAVETEK
MATERIAL N/A	PROJ ENGR		TITLE CARD CAGE, ASSY DRWG
	RELEASE APPROV Lisa M. Hoffman	2-3-89	
FINISH WAVETEK PROCESS N/A	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± N/A ANGLES XX ± °		
	DO NOT SCALE DWG		MODEL NO 24XX / DWG NO 0012-30-0115 / REV A
	SCALE NONE		CODE IDENT 34280 / SHEET 1 OF 1

0012-30-0115 REV. A

REVISIONS				
REV	DESCRIPTION	BY	DATE	PIN
A	RELEASE	EG	10/15/90	4938



	2410A
NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ARE:
FRACTIONS DECIMALS ANGLES
± .XX ± ±
.XXX ±

MATERIAL

FINISH

CONTRACT NO.

APPROVALS	DATE
DRAWN DJW/	5/11/90
CHECKED	

2410A

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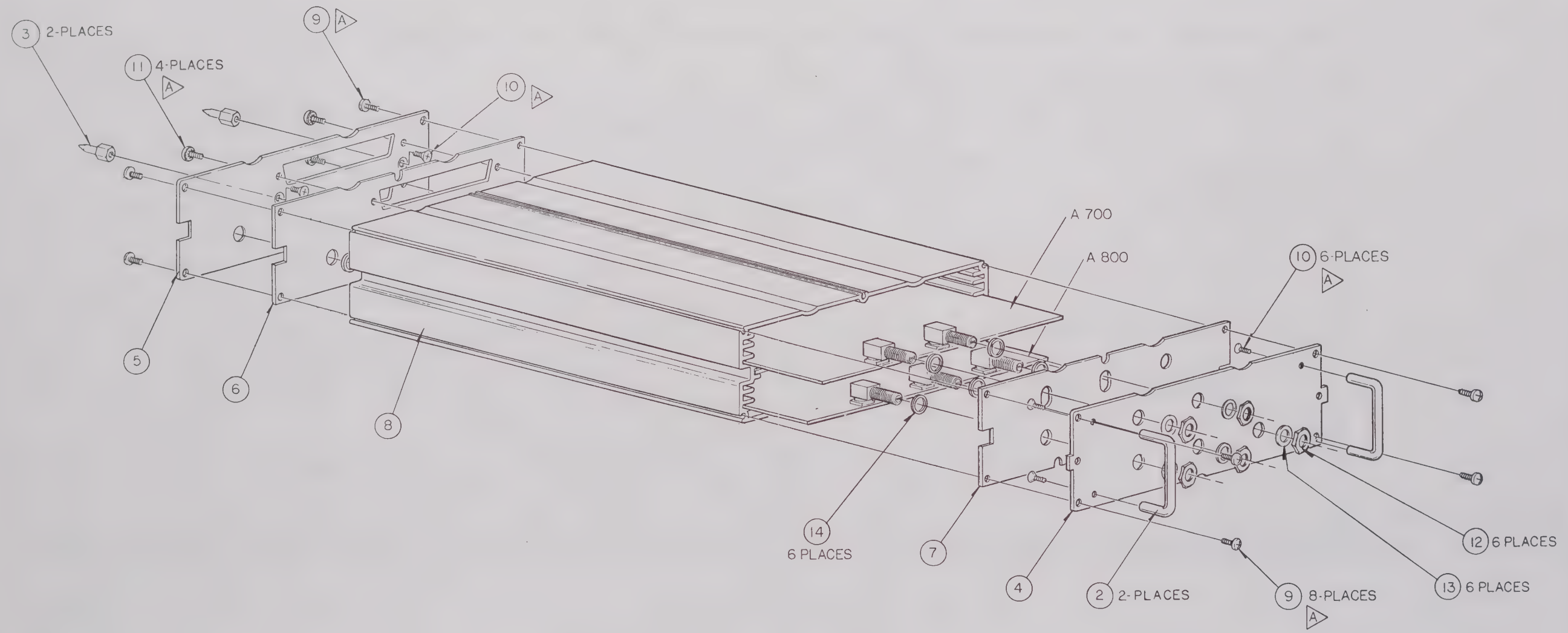
CARD CAGE CABLE LOCATION

SIZE	CODE IDENT NO.	DRAWING NO.	REV
B	34280	0012-10-0142	A

SCALE NONE | DO NOT SCALE DRAWING | SHEET 1 OF 1

REVISIONS				
REV	DESCRIPTION	BY	DATE	P.I.R.
A	DEL CENTER WALL	DW	4-89	4685
B	ADD ITEM #14	DW	5-89	4692
C	RELEASE	DW	5-89	4731



A TORQUE TO 4.7 IN-LBS

REF. BOM 1114-00-0534 (2405-2407)
1114-00-0539 (2410)

1114-00-0539	2410
1114-00-0534	2407
NEXT ASSY	USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: FRACTIONS ±, DECIMALS .XX ±, .XXX ±, ANGLES ±

CONTRACT NO.

MATERIAL

FINISH

APPROVALS	DATE
DRAWN	1-89
CHECKED	2-89
	2-3-89

REV. C

WAVETEK RF PRODUCTS, INC.

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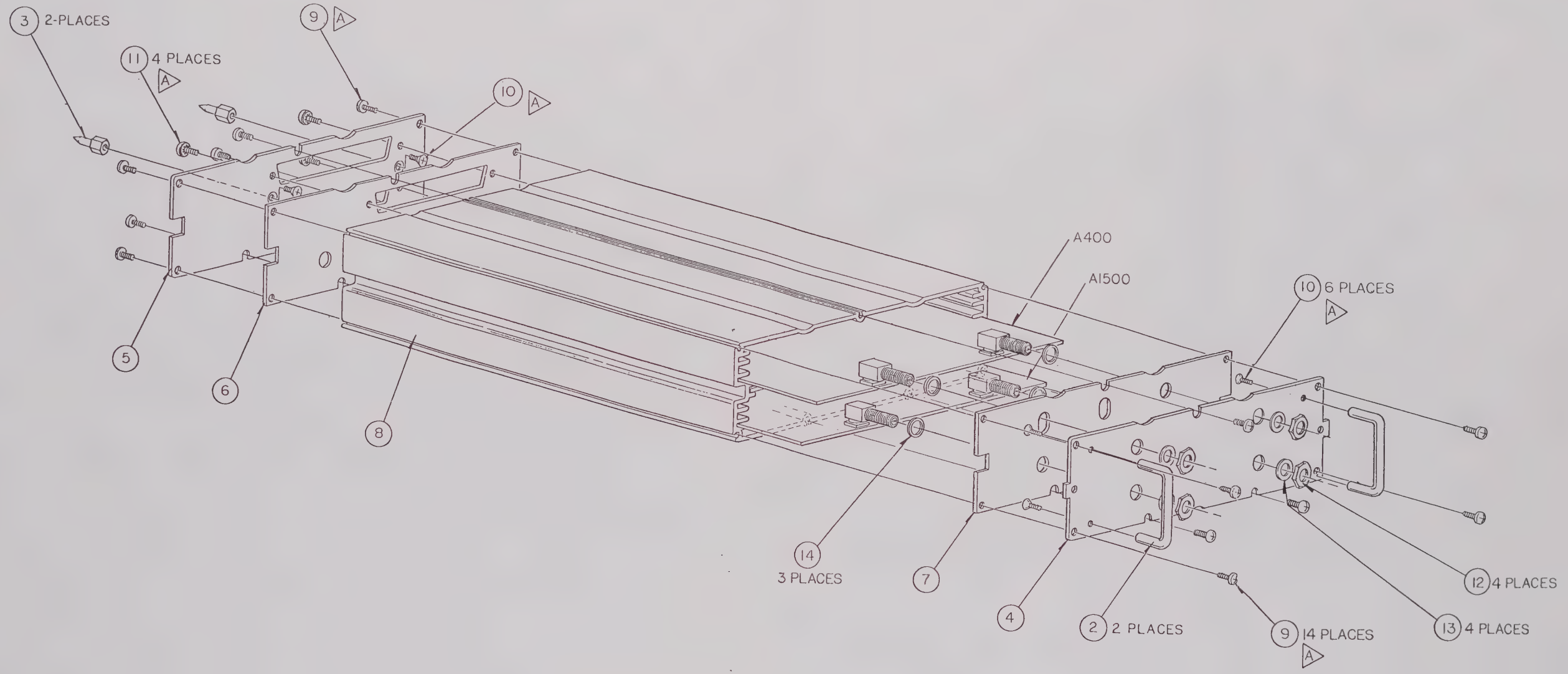
ENCLOSURE
AM/DIV AND OUTPUT, 24XX

SIZE	CODE IDENT NO.	DRAWING NO.
D	34280	0012-30-0131

SCALE NONE | DO NOT SCALE DRAWING | SHEET 1 OF 1

REVISIONS				
REV	DESCRIPTION	BY	DATE	P.I.N.
A	RELEASE	EG	4/1/1+	4921



A TORQUE TO 4.7 IN-LBS

REF. B.O.M. 1114-00-0541

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS DECIMALS ANGLES ± .XX ± .XXX ±	CONTRACT NO.
APPROVALS	DATE
DRAWN Pitts	8/30/90
CHECKED	
MATERIAL	
FINISH	
1114-00-0541 NEXT ASSY	USED ON
APPLICATION	2410A Rev.

WAVETEK RF PRODUCTS, INC.

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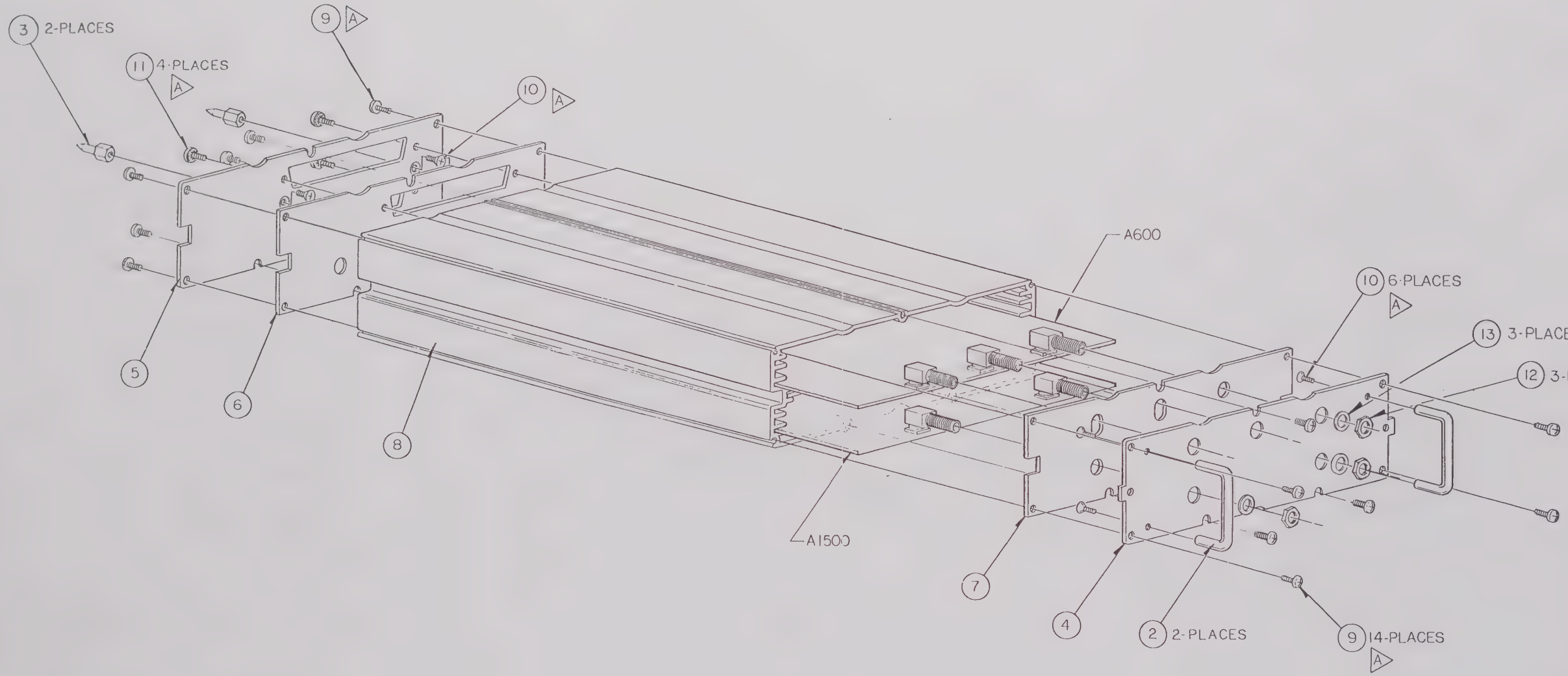
RF SYNTH & DOUB ENCL ASSY

SIZE	CODE IDENT NO.	DRAWING NO.
D	34280	0012-30-0173

SCALE NONE | DO NOT SCALE DRAWING | SHEET 1 OF 1

REVISIONS				
REV	DESCRIPTION	BY	DATE	P/N
A	RELEASE	EG	10/5/90	4938

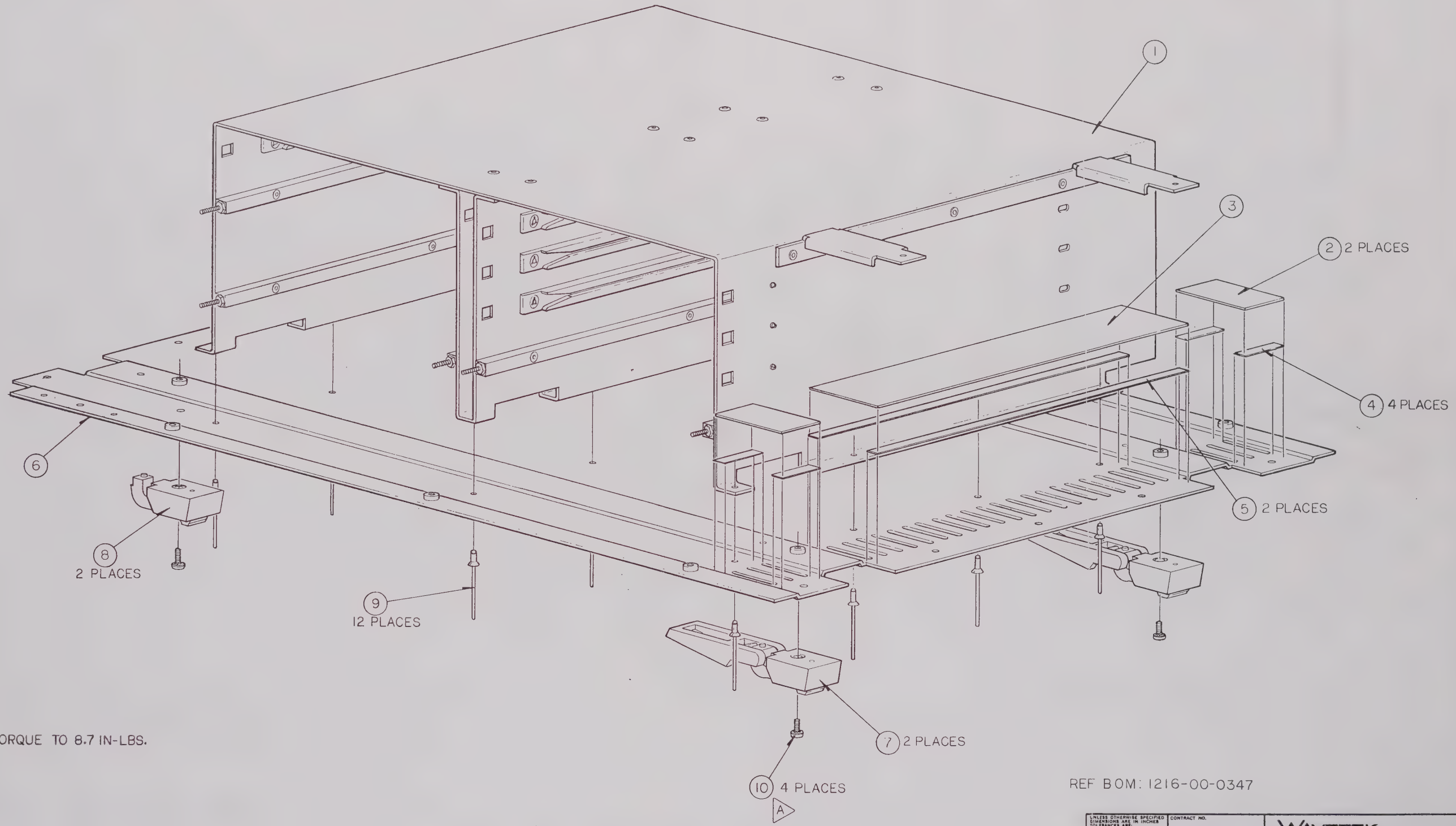


A TORQUE TO 4.7 IN-LBS

REF. B.O.M. 1114-00-0542

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE FRACTIONS DECIMALS ANGLES ± .XX ± .XXX ± ±	CONTRACT NO		WAVETEK RF PRODUCTS, INC.
	APPROVALS	DATE	This document contains information proprietary to Wavetek. The information in this document is not to be used or duplicated in any manner without the prior approval in writing of Wavetek.
	DRAWN Fillis	8/90	ENCLOSURE ASSY, LO/REF & REF SYNTH
MATERIAL	CHECKED		
FINISH		REV.	SIZE D · CODE IDENT NO 34280 · DRAWING NO 0012-30-0172
1114 00 0542 NEXT ASSY · 2410A USED ON	2410 A		SCALE NONE · DO NOT SCALE DRAWING · SHEET 1 OF 1
APPLICATION			

REVISIONS				
REV	DESCRIPTION	BY	DATE	P.I.N.
A	RELEASE	DW	4-89	4731



A TORQUE TO 8.7 IN-LBS.

REF BOM: 1216-00-0347

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ARE:
FRACTIONS DECIMALS ANGLES
± .XX ± ±
.XXX ±

MATERIAL

FINISH

NEXT ASSY	USED ON
1216-00-0347	24XX

APPLICATION

CONTRACT NO.

APPROVALS	DATE
DRAWN Fielder	1/89
CHECKED DJ Wood	2-89
Shaf Hussain	2-3-89

24XX

REV. A

WAVETEK RF PRODUCTS, INC.

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BOTTOM COVER ASSY.

SIZE	CODE IDENT NO.	DRAWING NO.
D	34280	0012-30-0126

SCALE NONE DO NOT SCALE DRAWING SHEET 1 OF 1

9-46

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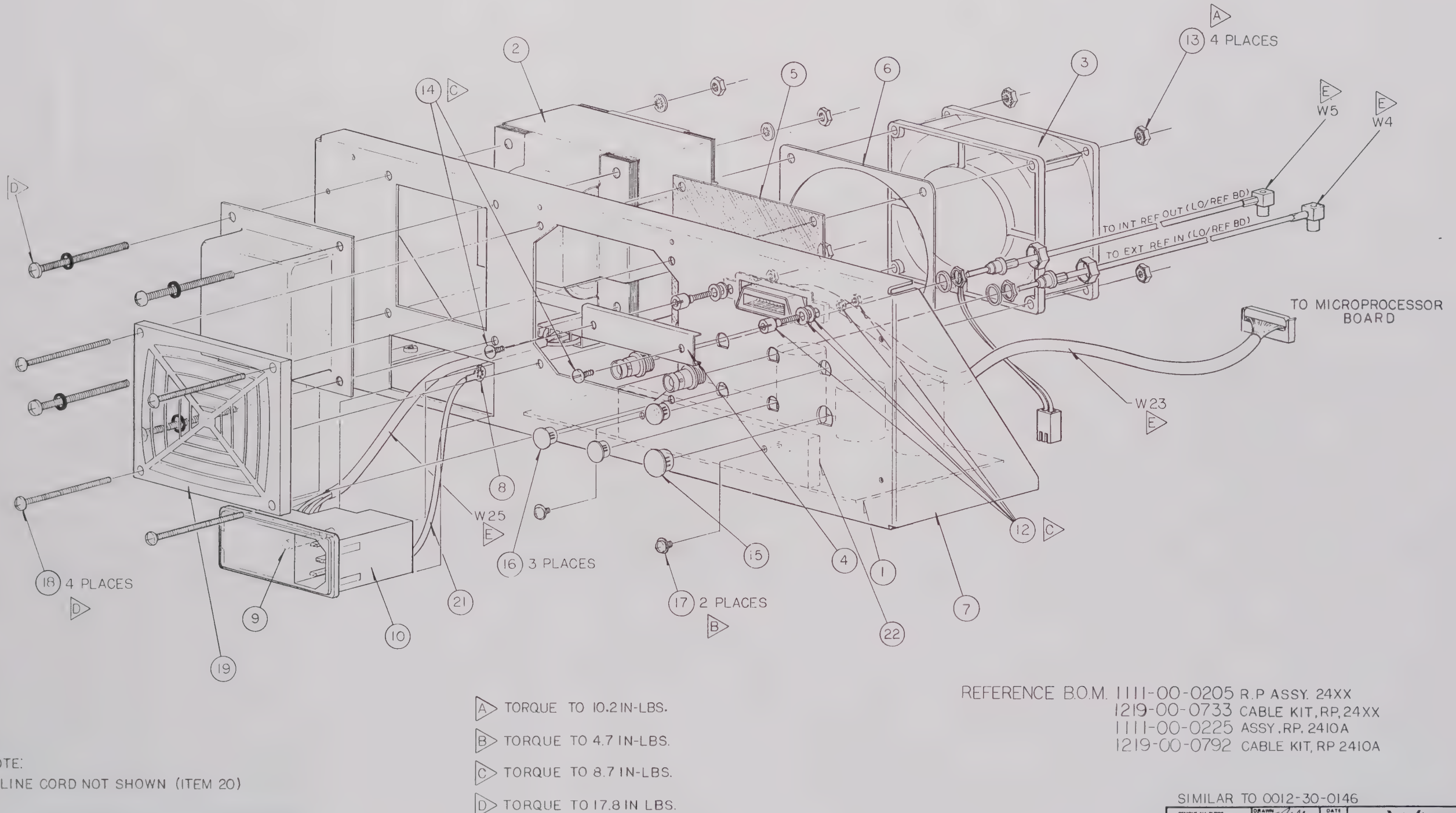
PIN #	REV	ECN	BY	DATE	APP
4731	A	RELEASE	DJ	4-89	
4944	B	ADDED REF BOMS, ITEM 17 AND ITEM 22	KJ	10/31/90	EK



NOTE:
- LINE CORD NOT SHOWN (ITEM 20)

A TORQUE TO 10.2 IN-LBS.

B TORQUE TO 4.7 IN-LBS.

C TORQUE TO 8.7 IN-LBS.

D TORQUE TO 17.8 IN LBS.

F THESE PARTS APPEAR ON THE R.P. CABLE KIT # 1219-00-0733 AND # 1219-00-0792 2410A

REFERENCE B.O.M. 1111-00-0205 R.P ASSY. 24XX
1219-00-0733 CABLE KIT, RP, 24XX
1111-00-0225 ASSY. RP. 2410A
1219-00-0792 CABLE KIT, RP 2410A

SIMILAR TO 0012-30-0146

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN [signature] DATE 1/89	WAVETEK
MATERIAL	PROJ ENGR [signature] 1/89	TITLE: REAR PANEL ASSY.
FINISH WAVETEK PROCESS	RELEASE APPROV 2-3 89 [signature]	
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± ANGLES ± XX ±	
	DO NOT SCALE DWG	MODEL NO 2407 / DWG NO 0012-30-0125 / REV B
	SCALE NONE	CODE IDENT 34280 / SHEET 1 OF 2

0012-30-0125 REV. B

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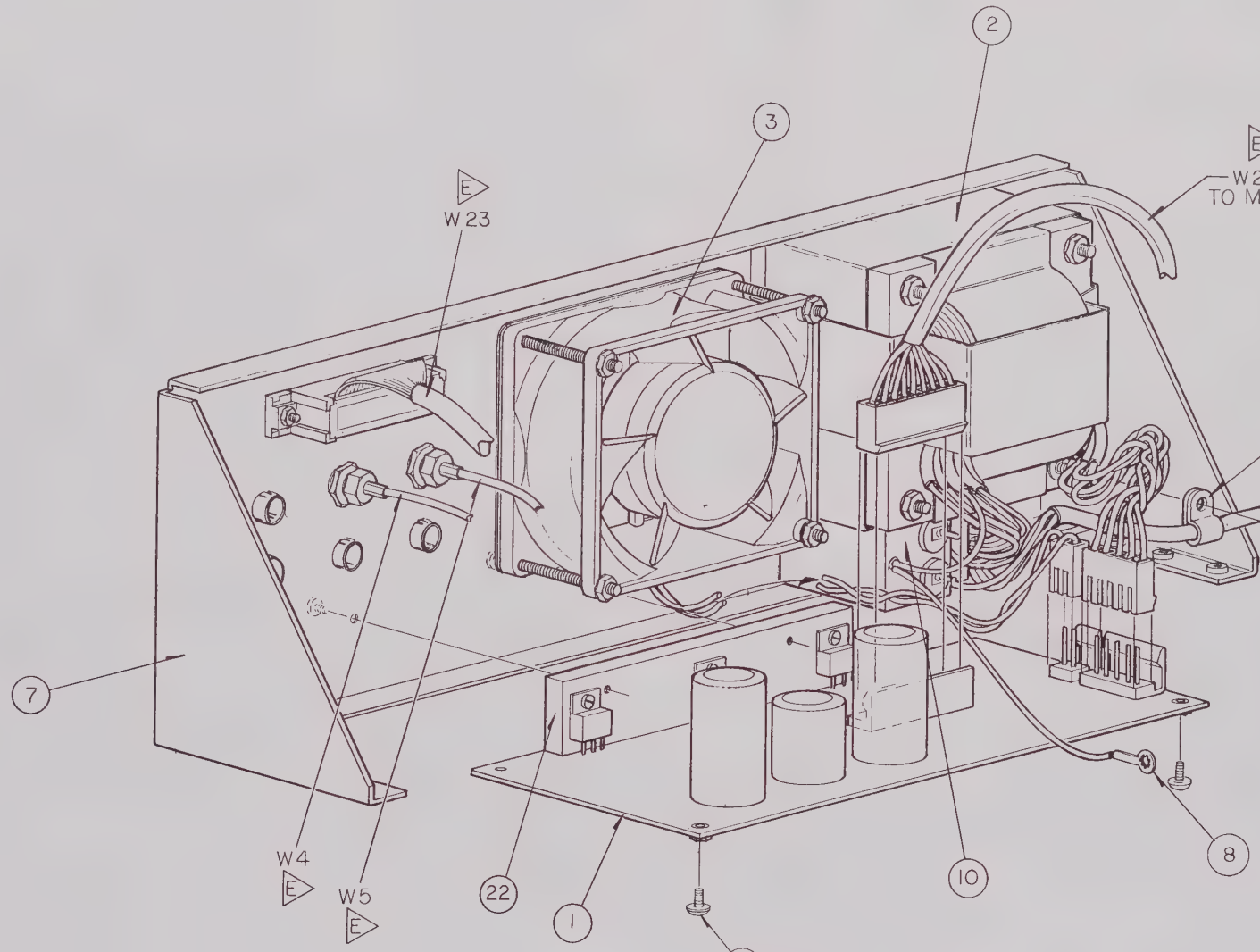
REV	ECN	BY	DATE	APP

SEE SHEET 1



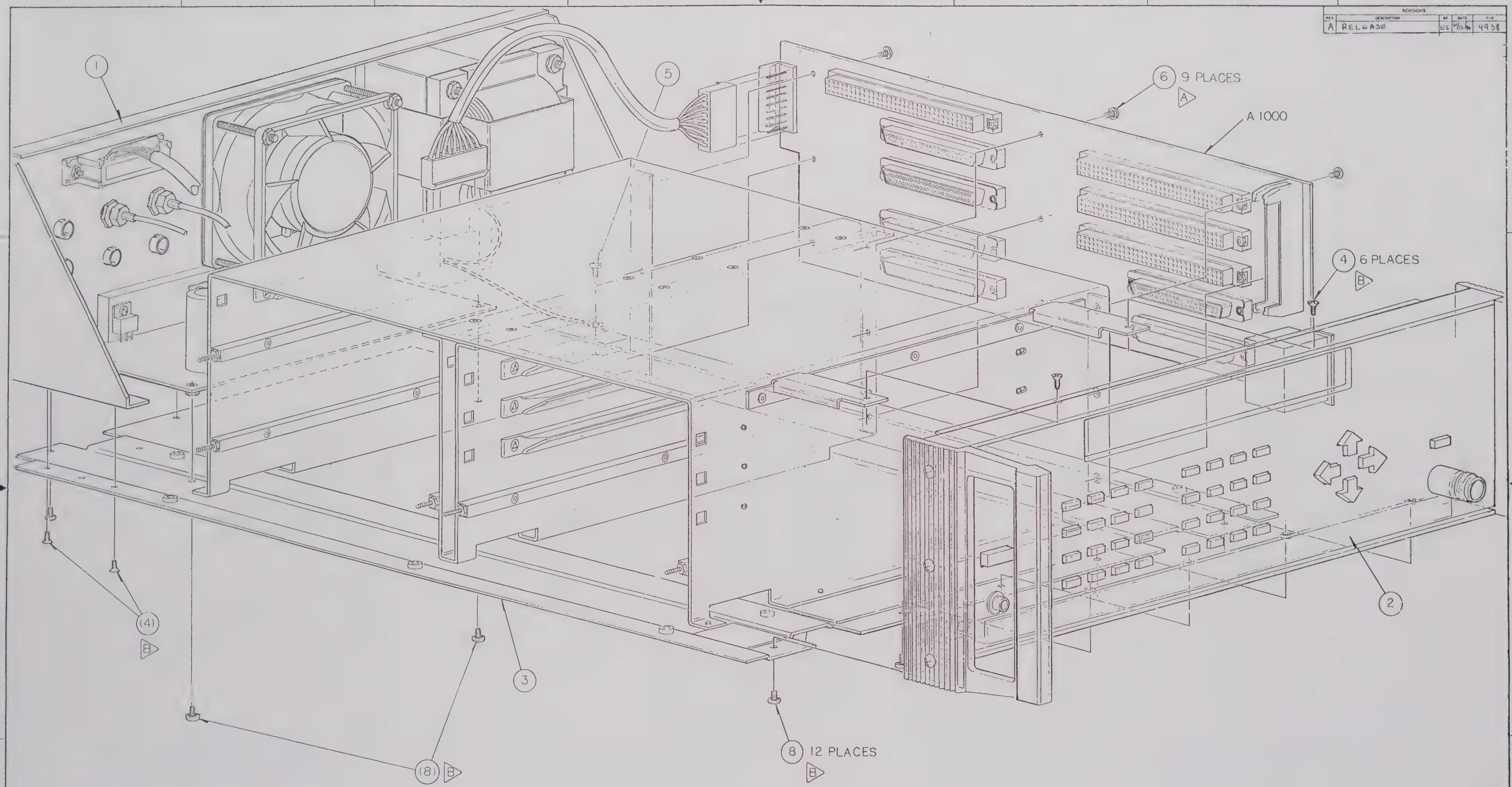
REFERENCE B.O.M. 1111-00-0205 R.P. ASSY., 24XX
1219-00-0733 CABLE KIT, RP, 24XX
1111-00-0225 ASSY, RP, 2410A
1219-00-0792 CABLE KIT, RP, 2410A

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN K Fields	DATE 1/89	WAVETEK
MATERIAL	PROJ ENGR	2/89	TITLE: REAR PANEL ASSY.
FINISH WAVETEK PROCESS	RELEASE APPROV Edward Huntsman	2-3-89	
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± ANGLES ± XX ±		
	DO NOT SCALE DWG	MODEL NO 2407	DWG NO 0012-30-0125 REV B
	SCALE NONE	CODE IDENT 34280	SHEET 2 OF 2

ΔD12-30-0125 REV B

9-48

REVISIONS				
REV	DESCRIPTION	BY	DATE	P.I.R.
A	RELEASE	EC	11/15/89	4938



A TORQUE TO 4.7 IN-LBS

B TORQUE TO 8.7 IN-LBS

REF. BOM 1111-00-0224 (2410A)

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: FRACTIONS ± / DECIMALS .XX ± .XXX ± / ANGLES ±	CONTRACT NO	WAVETEK RF PRODUCTS, INC.	
	APPROVALS: DRAWN [illegible] 8/90; CHECKED	CHASSIS ASSY.	
MATERIAL		SIZE D	CODE IDENT NO. 34280
FINISH		DRAWING NO. 0012-30-0170	
1111-00-0224 2410A (NEXT ASSY / USED ON)	2410A	REV.	SCALE NONE — DO NOT SCALE DRAWING — SHEET 1 OF 2
APPLICATION			

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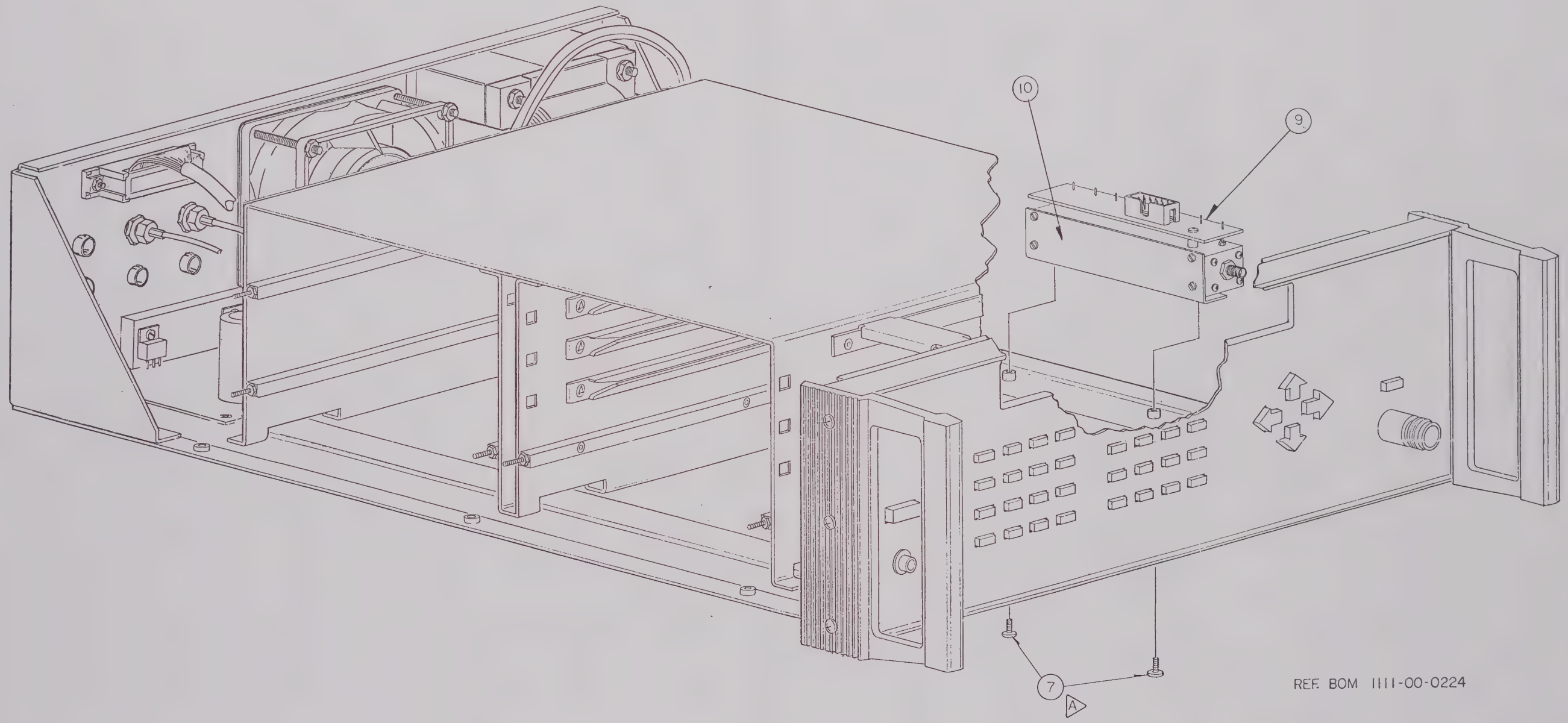
REVISIONS				
REV	DESCRIPTION	BY	DATE	PCN
	SEE SHEET 1			



REF. BOM 1111-00-0224

1111-00-0224	2410A
NEXT ASSY	USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ARE:
FRACTIONS DECIMALS ANGLES
± .XX ± ±
.XXX ±

MATERIAL

FINISH

CONTRACT NO.

APPROVALS	DATE
DRAWN L. Fields	8/90
CHECKED	

REV. 2410A

WAVETEK RF PRODUCTS, INC.

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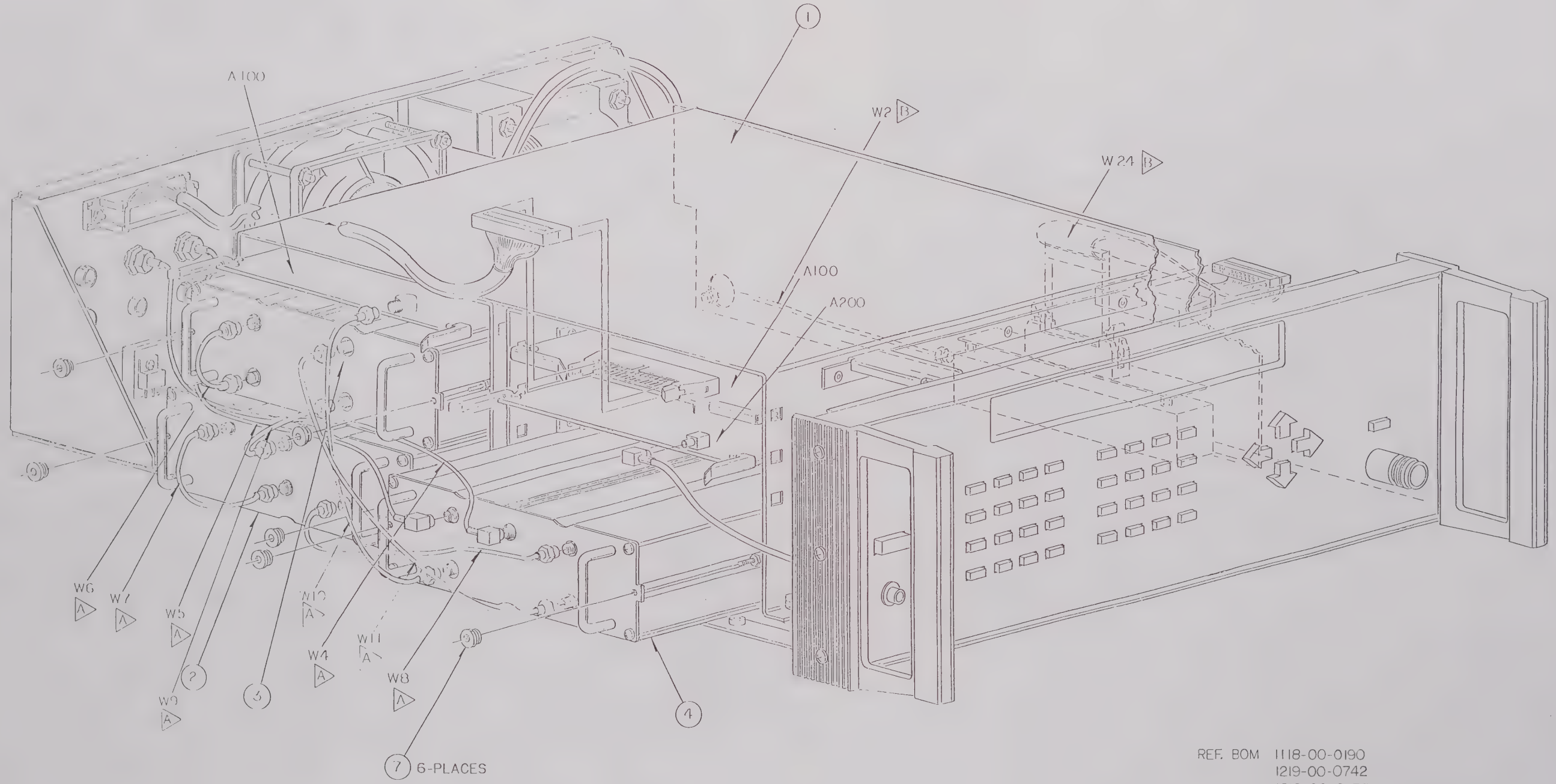
2410 CHASSIS ASSY. DWG.

SIZE	CODE IDENT NO.	DRAWING NO.
D	34280	0012-30-0170

SCALE NONE | DO NOT SCALE DRAWING | SHEET 2 OF 2

9-50

REVISIONS				
REV	DESCRIPTION	BY	DATE	P.I.N.
A	RELEASE	EG	4/6/90	99 38



REF. BOM 1118-00-0190
1219-00-0742
1219-00-0777

A (ITEM 5) THESE PARTS APPEAR ON B.O.M. 1219-00-0777

B (ITEM 6) THESE PARTS APPEAR ON B.O.M. 1219-00-0742

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE FRACTIONS DECIMALS ANGLES ± .XX ± .XXX ± ±	CONTRACT NO		WAVETEK RF PRODUCTS, INC.
	APPROVALS	DATE	
	DRAWN	8 90	This document contains information proprietary to Wavetek. The information in this document is not to be used or duplicated in any manner without the prior approval in writing of Wavetek.
MATERIAL	CHECKED		2410A FINAL ASSY DWG.
FINISH			SIZE D · CODE IDENT NO 34280 · DRAWING NO 0012-30-0171
1118 00 0190 / NEXT ASSY · 2410A / USED ON · APPLICATION	2410A	REV	SCALE NTS · DO NOT SCALE DRAWING · SHEET 1 OF 1

SECTION 10
REPLACEABLE PARTS LIST

10.1 INTRODUCTION

This section contains replaceable parts lists for the Model 2405/2410A. A complete parts list may have more than one page.

A part with a starred (*) value indicates that it is the nominal value that is shown for the particular part. A component with a slightly different value may be substituted for a starred part during calibration.

Parts lists titles may refer to "2045", "2407", "2410", "2410A", or "2475" units, or a combination of these numbers because their associated assemblies are used in more than one of the Wavetek 2400 series of signal generators. Any list in this section with a "2407" or a "2405" label also is used in the 2405/2410A unit.

10.2 MANUFACTURER CODES

Component manufacturers are identified by abbreviation codes on the Replaceable Parts Lists in this section. Complete manufacturer information (entire name, location, and FSCM number) for each manufacturer are shown immediately after the last of the parts lists.

10.3 ORDER OF PARTS LISTS

The parts lists begin immediately and are in the order shown in Table 10-1.

TABLE 10-1. ORDER OF REPLACEABLE PARTS LISTS

ASSY, FINAL, 2410A	1118-00-0190
WRAP UP KIT, 2410A	1111-00-0229
ENCL,LO/REF, 2410A	1114-00-0542
PC ASSY, LO/REF, 2410A	1110-00-2335
HYBRID PTS KIT, LO/REF, 2410A	1219-00-0774
PC ASSY, REF SYNTH, 2410A	1110-00-2338
ENCL, RF & DOUBLER, 2410A	1114-00-0541
PC ASSY, DBLR, 2410A	1110-00-2354
HYBID PTS, KIT, DOUBLER, 2410R	1219-00-0768
2410 DBL SWITHCHED FILTER BANK	1011-25-0004
PC ASSY, RF SYNTH, 2410A	1110-00-2337
PCB ASSY, VCO, 24XXA	1218-00-2628
ENCL, AM/DIV & OUTPUT, 2410A	1114-00-0543
PC ASSY, AM/DIV, 2410A	1110-00-2340
HYBRID PTS KIT, AM/DIV BD, 2410A	1219-00-0793
PC ASSY, OUTPUT, 2410A	1110-00-2341
HYBRID KIT, OUTPUT, 2410A	1219-00-0791
PC ASSY, CONTROL BD, 24XXA	1110-00-2359
HYBRID PTS KIT, CONTROL BD, 24XXA	1219-00-0804
PC ASSY, UPROC BD, 24XXA	1110-00-2360
PC ASSY, DDS, 2410A	1110-00-2336
EPROM KIT, DDS, 2410A	1219-00-0776
EPROM KIT, UPROC, 2410R	1219-00-0759
ASSY, CHASSIS, 2410A	1111-00-0224
CABLE KT, RF, 2410A	1219-00-0777
CABLE KT, ATTEN, 24XXA	1219-00-0810
TERMINATOR, 50 OHM	1118-40-9013
ATTEN ASSY, 2410	1219-00-0769
BOTTOM COVER ASSY, 24XXA	1216-00-0368
PC ASSY, MOTHER BD, 2410A	1110-00-2339
ASSY, FP, 2410A	1111-00-0223
PC ASSY, ATTEN INTFC,2410	1110-00-2333
CARD CAGE ASSY, 24XXA	1216-00-0369
ASSY, RP, 2410A	1111-00-0225
ASSY, FP MECH, 2410A	1216-00-0366
CABLE KIT, FP, 24XXA	1219-00-0807
LCD ASSY, 24XXA	1219-00-0808
KEYBD ASSY, 24XXA	1216-00-0370
XFMR ASSY, 24XXA	1219-00-0809
CABLE KIT, RP, 2410A	1219-00-0792
POWER SUPPLY, 24XXA	1115-00-0052
FAN ASSY, 24XXA	1219-00-0811
PC ASSY, P/S, 24XXA	1110-00-2370
HEATSINK ASSY, 24XXA	1216-00-0371

ABBR.	NAME.....	CITY.....	ST	CAGE.
35-S	THREE-FIVE SEMICONDUCTOR	TEMPE	AR	NONE
3M/CC	3M COMMERICAL CHEMICAL DIV	ST. PAUL	MN	28112
3M/EP	3M/ ELECTRONIC PRODUCTS DIV	ST. PAUL	MN	53387
3M/IS	3M / INDUSTRIAL SPECIALTIES DIV	ST. PAUL	MN	52152
A-B	ALLEN-BRADLEY	MILWAUKEE	WI	01121
A-D	ANALOG DEVICES	CAMBRIDGE	MA	24355
A-H	ARROW HART, INC.	KETTERING	OH	07858
A-I	ALAN INDUSTRIES	COLUMBUS	IN	52750
A-M	AMERICAN MAGNETICS	CARTERVILLE	IL	12715
A-S	ALEXANDER SCREW	INDIANAPOLIS	IN	NONE
A-Z	AMERICAN ZETTLER, INC.	IRVINE	CA	26806
A.T.	A.T. WALL CO.	WARWICK	RI	32716
AAVID	AAVID ENGINEERING,INC.	LACONIA	NH	30161
ABBIN	ABBOTT-INTERFAST CORP.	WHEELING	IL	08928
ABLST	ABLESTIK LABORATORIES	GARDENA	CA	21109
ABRAD	ABRADING SYSTEMS,CO.	ELGIN	IL	29789
ABSCA	ABSCOA INDUSTRIES	HAWTHORNE	NY	70127
ACI	ADVANCE COMPONENTS, INC.	CENTERBROOK	CT	28102
ACR	AMERICAN CHEMICAL REFINER	VILLA PARK	IL	1T842
ACRIN	ACRIAN	CUPERTINO	CA	58135
ADCRT	ADVANCED CIRCUIT TECHNOLOGY	NASHUA	NH	57034
ADV	ADVANCE PROCESS CO.	CHICAGO	IL	29431
AEG-T	AEG-TELEFUKEN CORP.	SOMERVILLE	NJ	24972
AEP	APPLIED ENG PRODUCTS	NEW HAVEN	CT	19505
AERTK	AERTECH INDUSTRIES	SUNNYVALE	CA	21847
AFE	ACCESSORIES FOR ELECTRONICS	BALDWIN	NY	54355
AFP	AIR FILTRATION PRODUCTS,INC	TUCSON	AZ	9Y422
AHAM	AHAM TOR INC.	ST RANCHO	CA	53894
AIN	ALPHA INDUSTRIES, INC.	WOBURN	MA	17540
ALASC	ALASCO RUBBER AND PLASTICS CORP	BURLINGAME	CA	13862
ALC	ALCO ELECTRONICS PRODUCTS	NORTH ANDOVER	ME	95146
ALDDV	ALLIED DEVICES CORP.	BALDWIN	NY	29964
ALENG	ALPHA ENG.	GREENWOOD	IN	46133
ALLAN	ALLAN WOODS AND ASSOC.	DES PLAINES	IL	NONE
ALLPL	ALL PLASTICS,INC.	INDIANAPOLIS	IN	9N350
ALMPT	ALPHA METALS, INC	JERSEY CITY	NJ	96613
ALP-S	ALPHA INDUSTRIES INC,SEMICONDUCTORS	WOBURN	MA	53536
ALPHA	ALPHA INDUSTRIES	LAWRENCE	MA	63596
ALPS	ALPS ELECTRIC (USA),INC	INDIANAPOLIS	IN	7J054
ALT	ALTEX ELECTRONICS,INC.	SAN ANTONIO	TX	
ALTRA	ALTERA CORP.	SANTA CLARA	CA	67183
AM-HE	AMSTER-HEISER CO	OAKWOOD	OH	
AMATM	AMATOM ELEC HDWE CO	NEW HAVEN	CT	1FJ15
AMD	ADVANCED MICRO DEVICES INC.	SUNNYVALE	CA	34335
AMELC	AMERICAN ELECTRIC CORDSETS	BENSENVILLE	IL	NONE
AMLAN	AMLAN, INC.	STAMFORD	CT	4J459
AMLFX	AMPLIFONIX	LONG HORNE	PA	
AMP	AMP, INC.	HARRISBURG	PA	00779

ABBR.	NAME.....	CITY.....	ST	CAGE.
AN-SP	ANTENNA SPECIALIST CO.	CLEVELAND	OH	
AND	TENNECO CO	PISCATAWAY	NJ	8N750
ANDER	S.W. ANDERSON CO.	DOWNERS GROVE	IL	03018
ANOG	ANOGRAPHICS	BURR RIDGE	IL	7S919
ANSLY	ANSLEY / THOMAS & BETTS COR P	LOS ANGELES	CA	15912
ANY	ANY SUITABLE SUPPLIER			NONE
ANZAC	ADAMS-RUSSELL,ANZAC DIV	BURLINGTON	MA	8B186
APL	AMPHENOL CONNECTOR SYSTEMS	BROADVIEW	IL	74868
APM	APM HEXSEAL CORP	ENGLEWOOD	NJ	97539
APP	ASSOCIATED ELECTRONICS/THRE E M (3M)	MENTOR	OH	63878
APPSP	APPLIED SPECIALTIES INC.	BELTSVILLE	MD	64998
APX	AMPEREX ELECTRONIC CORP.	SLATERSVILLE	RI	25403
ARC	ARCO ELECTRIC PRODUCTS	SHELBYVILLE	IN	24652
ARE	AMERICAN RESEARCH ENG.	ELGIN	IL	65832
ARGUS	ARGUS INTERNATIONAL	HOPWELL	NJ	51259
ARIES	ARIES ELECTRONICS CORP.	FRENCHTOWN	NJ	51167
ARN	ARNOLD ENGINEERING CO.	MARENGO	IL	95566
AROMT	AROMAT CORP.	ELK GROVE VILLAGE	IL	61529
ASBAG	ASSOCIATED BAG CO.	MILWAUKEE	WI	62777
ASC	ASSOCIATED SPRING	BRISTOL	CT	92830
ASM	ACCURATE SCREW MACHINE CO	NUTLEY	NJ	51506
ASPE	ASPE INC.	TOWACO	NJ	6T756
ASTID	ASTRO INDUSTRIES	DAYTON	OH	29365
AT/IN	ATLANTIC INDIA RUBBER CO	CHICAGO	IL	70485
ATC	AMERICAN TECHNICAL CERAMICS	HUNTINGTON STATN	NY	29990
ATLIN	ATLANTIC INDIA	CHICAGO	IL	
ATR	ATR COIL CO.	BLOOMINGTON	IN	NONE
AUGAT	AUGAT, INC.	ATTLEBORO	MA	91506
AULT	AULT INC.	MINNEAPOLIS	MN	14310
AUSPL	AUTOSPLICE	WOODSIDE	NY	
AUTCN	AUTOMATIC CONNECTOR, INC.	COMMACK	NY	94375
AUTCP	AUTOMATION COMPONENTS	PECKVILLE	PA	33498
AVDEL	AVDEL FASTENER SYS.	PARSIPPANY	NJ	19738
AVERY	AVERY LABEL	NEW BRUNSWICK	NJ	NONE
AVT	AVANTEK, INC.	SANTA CLARA	CA	24539
AVTEK	AVTEK INC	AURORA	NB	NONE
AVX	AVX CERAMICS DIV OF AVX COR P.	OLEAN	NY	96095
AVX-R	AVX CORP	RALEIGH	NC	
AWC	ALPHA WIRE	ELIZABETH	NJ	92194
AWP	ALMEGA WIRE PRODUCTS	BREMEN	IN	NONE
B-B	BURR-BROWN RESEARCH CORP.	TUCSON	AZ	13919
B-D	BECTON,DICKINSON,AND CO.	PARAMUS	NJ	06531
B-I	BUD INDUSTRIES,INC.	WILLOUGHBY	OH	
B-T	BEK-TEK, INC.	READING	PA	NONE
B-W	BARKER & WILLIAMSON	BRISTOL	PA	05690
BAHRS	BAHRS DIE AND STAMPING CO. INC.	CINCINNATI	OH	63416
BALL	MICROLITE INC	WESTFIELD	IN	NONE
BASLR	BASLER ELECTRIC	HIGHLAND	IL	NONE
BEARI	BEARINGS, INC.	CLEVELAND	OH	05469

ABBR.	NAME.....	CITY.....	ST	CAGE.
BEK	BECKMAN INSTRUMENTS, INC.	FULLERTON	CA	73138
BEL	BELDEN CORP.	GENEVA	IL	70903
BELFS	BELFUSE	XXXXX	XX	NONE
BELL	BELL INDUSTRIES	RANCHO DOMINGUEZ	CA	NONE
BER	BERG ELECTRONICS	NEW CUMBERLAND	PA	22526
BERQ	BERGQUIST	MINNEAPOLIS	MN	55285
BIRT	BIRTCHER CORP	EL MONTE	CA	33962
BIVAR	BIVAR INC	SANTA ANA	CA	32559
BLILY	BLILEY ELECTRIC CO.	WINDHAM	NH	
BOKER	BOKER'S INC.	MINNEAPOLIS	MN	85446
BOOT	BOONTON ELECTRONICS	RANDOLPH	NJ	
BORDN	BORDEN INC.	COLUMBUS	OH	32283
BOU	BOURNS, INC.	RIVERSIDE	CA	80294
BRAUN	BRAUN MFG CO	CHICAGO	IL	93785
BREZ	BREEZE CORPORATIONS, INC.	UNION	NJ	08484
BSCAN	B-SCAN, INC.	PHILADELPHIA	PA	32198
BSHP	BISHOP GRAPHICS, INC.	WESTLAKE VILLAGE	CA	34730
BUCK	BUCKEYE STAMPING CO.	COLUMBUS	OH	21604
BUD	BUD RADIO, INC.	WILLOUGHBY	OH	71218
BURND	BURNDY CORP.	NORWALK	CT	09922
BUS	BUSSMAN MFG.	ST. LOUIS	MO	71400
BUSCM	BUSCOM SYSTEMS,INC.	SANTA CLARA	CA	64623
C-A	CIRCUIT ASSEMBLY CORP	IRVINE	CA	52072
C-C	COMPOWER CORP.	SAN JOSE	CA	NONE
C-D	CORNELL DUBILIER ELECT DIV	NEWARK	NJ	14655
C-E	CLINTON ELECTRONICS	ROCKFORD	IL	54972
C-H	CUTLER-HAMMER, INC.	MILWAUKEE	WI	55841
C-I	COMPONENTS, INC.	BIDDEFORD	ME	17554
C-J	TRW/CINCH	ELK GROVE VILLAGE	IL	71785
C-K	C & K COMPONENTS, INC.	WATERTOWN	MA	09353
C-L	CENTRALAB DIV.	MILWAUKEE	WI	71590
C-M	C-M			NONE
C-W	C-W INDUSTRIES	WARMINSTER	PA	79727
CADBN	CADDEL-BURNS MFG.CO.,INC	MINEOLA	NY	04213
CAE	CAPAR COMPONENTS CORP	MELVILLE	NY	NONE
CAI	CUSTOM ACCESSORIES, INC.	SKOKIE	IL	NONE
CALEX	CALEX	PLEASANT HILL	CA	
CAM	CAMBION	CAMBRIDGE	MA	71279
CAPL	CADILLAC PLASTICS	INDIANAPOLIS	IN	1N836
CAPLG	CAPLUGS DIVISION PROTECTIVE CLOSURES CO, INC	BUFFALO	NY	
CAR	CARLING ELECTRIC, INC.	WEST HARTFORD	CT	73559
CAROL	CAROL CABLE CO.	PAWTICKET	RI	81774
CATMT	CATAMOUNT	LEOMINISTER	MA	01453
CBLWV	CABLEWAVE SYSTEMS, INC.	NORTH HAVEN	CT	16733
CBRDM	CARBORUNDUM INSUL DIV	NIAGARA FALLS	NY	NONE
CCM	CORCOM, INC.	LIBERTYVILLE	IL	05245
CDC	COMPONENT DEVELOPMENT CORP.	CARSON	CA	NONE
CECO	CENTRAL COIL CO.	BRAZIL	IN	NONE
CES	CES ELECTRONICS	WINTER PARK	FL	NONE
CFI	CIRCUIT FUNCTIONS INC.	NEWBURY PK	CA	32499
CGW	CORNING GLASS WORKS	CORNING	NY	24546
CH-EL	CH ELLIS CO, INC	INDIANAPOLIS	IN	
CH-MN	VCH INC	BUFFALO GROVE	IL	0CA01

ABBR.	NAME.....	CITY.....	ST	CAGE.
CHE	CHERRY ELECTRICAL PRODUCTS	WAUKEGAN	IL	01963
CHEMP	CHEMPLAST, INC. NORTON PERFORMANCE PLASTICS	WAYNE	NJ	18632
CHLAR	CHARLES LARSON CO.	STERLING	IL	35111
CHOM	CHOMERICS INC.	WOBURN	MA	18565
CHR	CHR INDUSTRIES	NEW HAVEN	CT	71643
CHTFD	CHATFIELD PAPER	CINCINNATI	OH	97361
CHWTR	CHARLES WALTERS PRODUCTS	WEST NEWTON	MA	63070
CIMCO	CIMCO WIRE AND CABLE INC.	ALLENDALE	NJ	6T091
CINML	CINCINNATI MILACRON MKTG.CO.	BLANCHESTER	OH	NONE
CINOX	CINOX CORP	CINCINNATI	OH	58997
CINTR	CIN-TRAN	CINCINNATI	OH	
CKI	CTS KNIGHTS, INC.	SANDWICH	IL	75378
CLA	CLAIREX CORP.	MT. VERNON	NY	03911
CLAR	CLAROSTAT MFG. CO	DOVER	NH	12697
CLCFT	COILCRAFT	CARY	IL	02113
CLFRM	COILFORM	GENEVA	IL	20254
CLFX	COLE-FLEX CORP.	BABYLON	NY	56352
CLMRK	CALMARK CORP	SAN GABRIEL	CA	52094
CMAG	CUSTOM MAGNETICS,INC.	NORTH MANCHESTER	IN	
CMD	CALIFORNIA MICRO DEVICES	MILPITAS	CA	
CMLC	CAMLOC FASTENER	PARAMUS	NJ	7G904
CMS	CURTIN MATHESON SCIENTIFIC, INC.	INDIANAPOLIS	IN	9N943
CN-C	CONNECTOR CORPORATION	CHICAGO	IL	16237
CNCRD	CONCORD ELEX	NEW YORK	NY	18310
CNTRN	CENTURION INTERNATIONAL INC.	LINCOLN	NE	65451
CNTRS	CONNECTRONICS	FRANKLIN	IN	43608
COAX	COAXIAL CONNECTORS,INC.	BRAINTREE	MA	NONE
COBAR	COBAR RESOURCES, INC.	CARROLLTON	TX	NONE
COL	COLLMER SEMICONDUCTORS INC	DALLAS	TX	1AA44
COLPI	COLE-PARMER INSTRUMENTS	CHICAGO	IL	
COMAD	COMPU ADD	AUSTIN	TX	
COMM	COMMODORE	WESTCHESTER	PA	NONE
COMP	COMPONENTS CORP.	DENVILLE	NJ	
COMPQ	COMPAQ COMPUTER CORP.	HOUSTON	TX	65685
CONDR	CONDOR ELECTRONICS	SUNNYVALE	CA	
CONRP	NEW ACT INC	CINCINNATI	OH	NONE
COORS	COORS PORCELAIN CO	GOLDEN	CO	14566
CORD	CORD ELECTRONICS	WESTBURY	NY	
COTO	COTO CORPORATION	PROVIDENCE	RI	
CPD	CELLULAR PRODUCTS DIST.	LOS ANGELES	CA	
CPI	COMPUTER PRODUCTS	POMPANO BEACH	FL	
CPKG	CREATIVE PKG DIV	INDIANAPOLIS	IN	NONE
CRDWL	CARDWELL CONDENSER CORP	LINDENHURST	NY	88356
CRFTK	CRAFTECH INDUSTRIES, INC	HUDSON	NY	51546
CRLST	CONTROLLED STATIC	SANTA FE SPRINGS	CA	39134
CRMGS	CERAMIC MAGNETICS INC.	FAIRFIELD	NJ	28733
CRMLY	CERMALLOY	WEST CONSHOHOCKEN	PA	18325
CRMSN	CRIMSON SEMICONDUCTOR	NY	NY	60943
CRT	CONDUCTIVE RUBBER TECHNOLOG	SANTA BARBARA	CA	NONE

ABBR.	NAME.....	CITY.....	ST	CAGE.
	Y			
CRTIS	CURTIS INDUSTRIES, INC.	MILWAUKEE	WI	73631
CRTR	CORE-TRONICS	ORANGE	NJ	29324
CRYLD	CRYSTALOID	HUDSON	OH	1CG97
CRYTK	CRYSTEK	FT. MEYERS	FL	1W476
CSCL	CUSTOM COIL INC.	ALCESTER	SD	NONE
CSDC	CONDITIONING SEMICNDTR DVS	WAYNE	NJ	60644
CSI	CONDUCTIVE SYSTEMS INC	AMSTERDAM	NY	64098
CSW	CENTRAL STEEL AND WIRE	CHICAGO	IL	11292
CTS	CHICAGO TELEPHONE SYSTEMS	CHICAGO	IL	71450
CTS-E	CTS OF ELKHART	ELKHART	IN	71450
CTS-F	C.T.S. OF FAIRBERRY	FAIRBERRY	IL	71450
CTS-K	CTS OF KEENE	PASO ROBLES	CA	11237
CTS-S	CTS MICROELECTRONICS, INC.	SANDWICH	IL	
CTSBR	CTS OF BERNE	BERNE	IN	11236
CTSBV	CTS OF BROWNSVILLE	BROWNSVILLE	TX	34263
CTYSP	CENTURY SPRING CO.	LOS ANGELES	CA	56988
CURT	CURTIS ELECTRO DEVICES,INC.	MOUNTAIN VIEW	CA	54719
CURTI	CURTIS INSTRUMENTS, INC.	KISCO	NY	18583
CW	CW INDUSTRIES	SOUTHAMPTON	PA	
CW/AL	C.W./ALPHA	SOUTHAMPTON	PA	NONE
CWY	CWY	LAFAYETTE	IN	NONE
CXLCN	COAXIAL CONNECTOR	BRAINTREE	MA	NONE
CYPRS	CYPRESS SEMICONDUCTOR	SAN JOSE	CA	65786
D-S	DATA SIGNAL	ALBANY	GA	1V200
DABRN	DABURN ELECTRONICS,INC.	NORWOOD	NJ	25706
DAIWA	DAIWA CRYSTAL	OVERLAND PARKS	KS	NONE
DAL	DALE TECHNOLOGY CORP.	HARTSDALE	NY	8R931
DALE	DALE ELECTRONICS INC	COLUMBUS	NE	91637
DATEL	DATEL SYSTEMS, INC.	MANSFIELD	MA	50721
DATRO	DATRON INSTRUMENTS LTD.	NORWICH	UK	NONE
N				
DAV	HARRY DAVIES MOLDING CO.	CHICAGO	IL	72512
DAYTN	DAYTON ELECTRIC CO.	CHICAGO	IL	16327
DBPWR	D & B POWER, INC	BAYSHORE	NY	
DEL	DELEVAN DIV.	EAST AURORA	NY	99800
DELFO	DELTA FOREMOST	INDPLS	IN	
DELKR	DELKER CORPORATION	BRANFORD	CT	4T594
DEN	DENNISON MFG. CO.	FRAMINGHAM	MA	16956
DERGR	DERINGER MFG.	MUNDELEIN	IL	NONE
DEUTS	DEUTSCH RELAYS,INC.	E. NORTHPORT	NY	NONE
			.	
DEW	DEWIRE FABRICATING CORP.	LOWELL	MA	13161
DGTRN	DIGITRAN CO.	PASADENA	CA	07126
DI/O	DATA I/O	REDMOND	WA	
DIASH	DIAMOND SHAMROCK			NONE
DICO	DICONIX	DAYTON	OH	
DIGKY	DIGI-KEY CORP	THIEF RIVER FALLS	MN	
DILEC	DILECTRON	MONROVIA	CA	NONE
DIO	DIODES, INC.	CHATSWORTH	CA	12060
DIXON	DIXON INDUSTRIES INC.	BRISTOL	RI	04813
DK-WR	DAKO-WARE	CHICAGO	IL	NONE
DLGHT	DIALIGHT	BROOKLYN	NY	72619
DLI	DIELECTRIC LABORATORIES INC	CAZENVIA	NY	55153

ABBR.	NAME.....	CITY.....	ST	CAGE.
DLLAS	DALLAS SEMICONDUCTOR CORP	DALLAS	TX	NONE
DLTEM	DELTA ELECTRONICS MFG CO	BEVERLY	MA	00795
DM-GY	DIMCO-GRAY	CENTERVILLE	OH	80813
DODGE	DODGE CORK COMPANY INC.	LANCASTER	PA	72667
DOWCG	DOW CORNING CORP.	MIDLAND	MI	71984
DRA	DRAKE MANUFACTURING CO.	HARWOOD HEIGHTS	IL	71744
DRBRN	DEARBORN WIRE & CABLE CO.	ROSEMONT	IL	28105
DRMYR	DORMEYER	ROCKVILLE	IN	73662
DSTCO	DESTACO	TROY	MI	NONE
DUFST	DUOFAST	INDIANAPOLIS	IN	NONE
DUPNT	E.I.DUPONT DENEMOURS & CO	WILMINGTON	DE	NONE
DYETC	DYETCHING COMP.	INDIANAPOLIS	IN	NONE
DYNA	DYNACHEM CORP.			NONE
E-C	ELECTRONIC CRYSTALS	KANSAS CITY	MO	18853
E-E	E&E NAMEPLATE	GALION	OH	NONE
E-I	ELECTRICAL INDUSTRIES,INC.	MURRAY HILL	NJ	20093
E-L	E-L PRODUCTS CO	EAST AURORA	NY	14550
E-M	ELECTRA/MIDLAND CORP.	MINERAL WELLS	TX	NONE
EAC	ELECTRONIC APPLICATIONS CO	EL MONTE	CA	21317
EAI	EUROPEAN AMERICAN INDUSTRIES	NORTHFIELD	IL	NONE
EAST	EASTLAND ELECTRONICS	HAUPPAUGE	NY	NONE
EATON	EATON CORP.	SUNNYVALE	CA	34657
EBM	EBM INDUSTRIES, INC.	UNIONVILLE	CT	62292
EBY	EBY COMPANY	PHILADELPHIA	PA	72825
ECELT	EC ELECTRONICS	GRAND RAPIDS	MI	NONE
ECG	PHILLIPS ECG	WALTHAM	MA	NONE
ECKDT	ECKARDT LABORATORIES	ORANGE	CA	61874
ECMC	ELECTRI-CORD MFG. CO. INC.	WESTFIELD	PA	NONE
ECNMT	ECONOMITE (ITW SWITCHES)	CHICAGO	IL	22753
EDAC	EDAC, INC.	DON MILLS, ONT., CANADA	**	31781
EDS	E.D.S.	DANVILLE	VA	
EECO	EECO, INC.	SANTA ANA	CA	97525
EKS	ELECTRO-KINETIC SYSTEMS,INC.	TRAINER	PA	63771
EL-DV	ELECTRONIC DEVICES	YONKERS	NY	NONE
ELANT	ELANTEC	MILPITAS	CA	
ELC-I	ELECTRA	CUMBERLAND	IN	63685
ELCHM	ELECTROCHEM INDUSTRIES	CLARENCE	NY	
ELCO	ELCO INDUSTRIES	ROCKFORD	IL	83486
ELCOC	ELCO CORPORATION	LAGUNA HILLS	CA	
ELCPT	ELECTRONIC CONCEPTS INC	EATONTOWN	NJ	50558
ELDRE	ELDRE COMPONENTS, INC	ROCHESTER	NY	19648
ELHDW	ELECTRONIC HARD	FARMINGDALE	NY	23480
ELNA	ELNA	CARSON	CA	64013
ELOCB	ELECTRO CUBE, INC.	SAN GABRIEL	CA	14752
ELSTN	ELSTON ELECTRONICS CORP.	GENEVA	NY	56746
ELVT	ELECTROVERT	NEW ROCHELLE	NY	06229
EM-CM	EMERSON & CUMING,INC	CANTON	MA	3D421
EMC	EMC SHIELDING	GARDEN GROVE	CA	64411
EMHFG	EMHART FASTENER GROUP	SHELTON	CT	NONE

ABBR.	NAME.....	CITY.....	ST	CAGE.
EMM	EMMTRONICS	INDIANAPOLIS	IN	3P054
ENTHN	ENTHONE INC.	NEW HAVEN	CT	02258
EPITK	EPITEK ELECTRONICS	KANATA,ONT,CANADA	**	37907
EPOXT	EPOXY TECHNOLOGY, INC.	BILLERICA	MA	33246
EPSON	EPSON AMERICA,INC.	TORRANCE	CA	61722
ERG	ENDICOTT RESEARCH GROUP,INC	ENDICOTT	NY	63312
ERNI	ERNI COMPONENTS	RICHMOND	VA	
ESP	ESP	EAST PROVIDENCE	RI	
ESTRN	EASTERN INTERNATIONAL	BLOOMINGTON	IN	NONE
ETC	ELECTRONIC TRANSISTOR CORP.	FLUSHING	NY	12045
ETP	ERIE TECHNOLOGICAL PRODUCTS	ERIE	PA	72982
ETRI	ETRI INC.	MONROE	NC	60856
ETROL	ELEC-TROL INC.	SAUGUS	CA	15636
EVRDY	EVEREADY	NEW YORK	NY	59717
EWC	EWC INC.	KENILWORTH	NJ	15387
EXAR	EXAR INTEGRATED SYSTEMS	SUNNYVALE	CA	52063
EXCEL	EXCELSIOR HARDWARE CO.	STAMFORD	CT	21192
EZHK	E-Z HOOK DIV/TEKTEST INC.	ARCADIA	CA	08505
EZLOK	E-Z LOCK DIV/TOOL COMPONENTS INC	GARDENIA	CA	52478
F-K	THERMWELL PRODUCTS, INC.	FRAMINGHAM	MA	NONE
F-S	FEDERAL SCREW	CHICAGO	IL	73734
FAN	FANCOURT & CO.	GREENSBORO	NC	NONE
FASTX	FASTEX DIV.,ILL.TOOL WORKS	DES PLAINES	IL	NONE
FCD	FAIRCHILD	MOUNTAIN VIEW	CA	07263
FCI	FILM CAPACITORS, INC.	PAS SALC	NJ	00686
FID	FIDELITY			NONE
FISH	FISHER SCIENTIFIC			NONE
FJTSU	FUJITSU MICROELECTRONICS INC	SANTA CLARA	CA	61271
FNWL	FENWAL	FRAMINGHAM	MA	15801
FOX	FOX	FORT MYERS	FL	
FRDKS	FREDERICKS CO.	HUNTINGDON VALLEY	PA	89597
FRK	FRAKO	FRANKFORT, GER.	**	NONE
FRQSS	FREQUENCY SOURCES INC. SOURCES DIV	CHELMSFORD	MA	26629
FRRNT	FERRANTI ELECTRIC, INC.	COMMACK	NY	22119
FRSCI	FISHER SCIENTIFIC	ST. LOUIS	MO	80011
FRTC	FERRITRONICS,INC.	NIAGARA FALLS	NY	
FRTE	FAIR RITE PRODUCTS CORP.	WALLKILL	NY	34899
FRXC	FERROXCUBE DIVISION	SAUGERTIES	NY	02114
FSTSP	FASTENER SPECIALTY	GRAND PRAIRE	TX	
FUT	FUTABA			NONE
G-E	GENERAL ELECTRIC	INDIANAPOLIS	IN	24446
G-H	GRAYHILL, INC.	LA GRANGE	IL	81073
G-I	GEN'L INSTRUMENT SEMICNDTR	HICKSVILLE	NY	14963
G-T	GRAND TRANSFORMERS	GRAND HAVEN	MI	02459
GAL	GALILEO ELECTRO-OPTICS	STURBRIDGE	MD	28719
GARRY	GARRY DIV.	NORTH BRUNSWICK	NJ	19112
GATES	GATES ENERGY PROD.	DENVER	CO	57053
GBN	GILBERT ENGINEERING CO.,INC	PHOENIX	AZ	82316

ABBR.	NAME.....	CITY.....	ST	CAGE.
GCE	GC ELECTRONICS	ROCKFORD	IL	80112
GILMN	GILLMAN	INDPLS	IN	NONE
GLNMC	GLENMARC MFG. CO.	NORTHBROOK	IL	59323
GLOBE	GLOBE	MILWAUKEE	WI	NONE
GLSTL	GLASTEEL INDUSTRIAL LAMINATES	DUARTE	CA	NONE
GM-NP	GM NAMEPLATE,INC.	SEATTLE	WA	22670
GNBRC	GENERAL BEARING CORP.	WEST NYACK	NY	09721
GNDVC	GENERAL DEVICES CO.	INDIANAPOLIS	IN	06666
GNRAD	GENRAD INC	CONCORD	MA	24655
GOU	GOULD, INC.	ST. PAUL	MN	55857
GPE	GOLDEN PACIFIC ELECTRONICS	PLACENTIA	CA	
GRANT	GRANT PULLEY & HARDWARE CO	WEST NYACK	NY	NONE
GRBON	GRAB-ON	WALLAWALLA	WA	
GREAM	GENERAL RESEARCH OF ELECTRONICS	JAPAN	**	
GRVPN	GROOV-PIN CORP	RIDGEFIELD	NJ	73957
GSTAR	GOLD STAR TECH, INC.	SUNNYVALE	CA	
GTR	GTR ENTERPRIZES,INC.	EDINBURGH	IN	
GUDL	GUDEBROD BROS. SILK CO.	CHICAGO	IL	NONE
GWNDA	GOWANDA ELEX CORP	GOWANDA	NY	24226
GWY	GILWAY TECHNICAL LAMP	WOBURN	MA	
H-H	HANDY & HARMON	NEW YORK	NY	73977
H-P	HEWLETT-PACKARD	INDIANAPOLIS	IN	28480
HAMMO	HAMMOND MFG.	BUFFALO	NY	
HARTW	HARTWELL CORP.	PLACENTIA	CA	83014
HAVCA	HAVERHILL CABLE & MANUFACTURING	HAVERHILL	MA	65344
HAYES	HAYES MICROCOMPUTOR PRODUCTS,INC.	NORCROSS	GA	63730
HDWSP	HARDWARE SPECIALTY CO	LONG ISLAND CITY	NY	07679
HEC	HOPKINS ENGINEERING CO.	SAN FERNANDO	CA	02777
HEXAC	HEXACON	ROSELLE PARK	NJ	
HEYCO	HEYCO MOLDED PRODUCTS	KENILWORTH	NJ	28520
HGHS	HUGHES SOLID-STATE PROD	NEWPORT BEACH	CA	NONE
HHS	KULKA SMITH	BROOKLYN	NY	83330
HI-G	HI-G INC	WINDSOR LOCKS	CT	02289
HIROS	HIROSE ELECTRIC,INC.	CHATSWORTH	CA	
HIT	HITACHI AMERICA, LTD.	SAN FRANCISCO	CA	62786
HL-MK	HALL-MARK ELECT.	INDIANAPOLIS	IN	1JW33
HLMBG	HOLMBURG	INMAN	SC	NONE
HMLN	HAMLIN	LAKE MILLS	WI	12617
HNKL	HENKEL ADHESIVES CO.	MINNEAPOLIS	MN	NONE
HOLGW	HOLLINGSWORTH SLDRLS TERM.	POTTSTOWN	PA	14726
HOLUB	HOLUB DISTRIBUTING CO.	NEWPORT	KY	NONE
HOWI	HOWARD INDUSTRIES	MILFORD	IL	
HRMTT	HERMETITE CORP.	AVON	MA	04302
HSD	HARRIS CORP. SEMICDR. DIV.	MELBOURNE	FL	27410
HUD	HUDSON TOOL & DIE CO.	NEWARK	NJ	02875
HWDN	HOWDEN CO.	NEWARK	OH	NONE
HWRD	CYCLOPS INDUSTRIES INC/HOWARD	MILFORD	IL	81041

ABBR.	NAME.....	CITY.....	ST	CAGE.
HY-Q	HY-Q INTERNATIONAL (USA) IN C.	ERLANGER	KY	
HY/PL	HYDRO PLASTICS INC.	GEORGETOWN	KY	NONE
HYNDI	HYUNDIA ELECTRONICS AMERICA	SANTA CLARA	CA	NONE
HYSOL	HYSOL CORP	INDUSTRY	CA	12405
HYSYS	HYBRID SYSTEMS	BEDFORD	MA	33256
HYT	HYTRONICS	PINELLAS PARK	FL	29525
I-S	INSTRUMENT SPECIALTIES CO., INC.	DELAWARE WATER GA P	PA	34641
I/OT	I/O TECH	CLEVELAND	OH	
IBNCO	INDIANA BOLT AND NUT CO.	INDIANAPOLIS	IN	8N395
ICI	ILLINOIS CAPACITOR INC.	MORTON GROVE	IL	74840
ICO-R	ICO-RALLY	PALO ALTO	CA	51705
ICT	INTERNATIONAL CMOS TECHNOLO GY,INC.	SAN JOSE	CA	
IEE	INDUSTRIAL ELECTRONIC ENG	NORTH HOLLYWOOD	CA	05464
IERC	INT'L ELEC. RESEARCH CORP.	BURBANK	CA	98978
IMB	IMB ELECTRONICS PRODUCTS, I NC	SANTA FE SPRINGS	CA	27556
IMC	INDIANA MODEL,INC.	INDIANAPOLIS	IN	NONE
IMI	INTERNATIONAL MICROCIRCUITS , INC	MILPITAS	CA	
IMS	IMS EQUIPMENT, INC.	IRVINE	CA	1V719
INDAL	INDIUM CORP. OF AMERICA	SYRACUSE	NY	NONE
INDEC	INDUSTRIAL ELECTRONIC HDWR.	NEW YORK	NY	97913
INDFS	INDUSTRIAL FASTENERS CORP.	PORT WASHINGTON	NY	84992
INDGL	INDIANA GENERAL	KEASBEY	NJ	72656
INDSP	INDUCTOR SUPPLY INCORP	ORANGE	CA	
INDV	INDUSTRIAL DEVICES	EDGEWATER	NJ	91802
INEC	INTEL EXPORTS CORP	BOMBAY	IN DI A	
INFAN	INTERFAN	BURLINGAME	CA	
INIMP	INTERNATIONAL IMPORTERS	CHICAGO	IL	NONE
INLOK	INTERLOK/WM J PURDY CO.	BURLINGAME	CA	55951
INSPK	INSTAPAK DIV.	DANBURY	CT	51614
INT	INTERSIL, INC.	CUPERTINO	CA	32293
INTEL	INTEL CORP	SANTA CLARA	CA	34649
INTGR	INTEGRATED DEVICE TECHNOLOG Y,INC	SANTA CLARA	CA	61772
INTPD	INTEGRATED POWER DESIGNS	LAWRENCEVILLE	NJ	
INTVX	HONEYWELL INC MARINE SYSTEM S DIV	EVERETT	WA	82277
INWEB	INTERNATIONAL WEBBING	WHITEHALL	PA	32860
IRC	INTERNATIONAL RESISTANCE CO	PHILADELPHIA	PA	75042
IREC	INT'L RECTIFIER CORP.	LOS ANGELES	CA	81483
IRR	INDUSTRIAL RETAINING RING C O	IRVINGTON	NJ	97464
ISC	INLAND SPECIALTY CHEMICAL	COSTA MESA	CA	59987
ISL	ISL PRODUCTS INTERNATIONAL LTD	SYOSSET	NY	
ISTMP	ISOTEMP RESEARCH, INC.	CHARLOTTESVILLE	VA	31785

ABBR.	NAME.....	CITY.....	ST	CAGE.
ITRON	ISE ELECTRONICS	ISE,JAPAN	**	NONE
ITT	INT'L TELEPHONE & TELEGRAPH	W. PALM BEACH	FL	NONE
ITT-C	ITT-CANNON	FOUNTAIN VALLEY	CA	71468
ITT-P	ITT POMONA ELECTRONICS	NORTHBROOK	IL	NONE
ITT-S	ITT SHADOW	EDEN PRAIRIE	MN	
JACK	JACKSON BROTHERS(LONDON)LTD	LONDON	EN GL AN D	
JAMES	JAMES ELECTRONICS	CHICAGO	IL	12749
JBM	JBM ELECTRONICS, INC.	MANCHESTER	NH	62694
JEF	JEFFERS	DUBOIS	PA	97469
JEW	JEWELL ELECTRICL INST	MANCHESTER	NH	33005
JFD	JFD ELECTRONICS	BROOKLYN	NY	73899
JFW	JFW INDUSTRIES	BEECH GROVE	IN	56532
JHSN	JOHANSON MFG. CORP.	BOONTON	NJ	91293
JOHNC	JOHNSON CONTROLS,INC.	MILWAUKEE	WI	
JON	E.F. JOHNSON CO.	WASECA	MN	74970
JRBT	JACK RABBIT,INC.	SALEM	PA	NONE
JROME	JEROME INDUSTRIES CORP.	KENILWORTH	NJ	NONE
JST	JS TERMINAL CORP AMERICA	ELK GROVE	IL	8Z573
JUDD	JUDD WIRE DIV. ECC	TURNERS FALLS	MA	12703
K-L	KERRIGAN LEWIS MFG.	CHICAGO	IL	73920
K-S	K & S ENGINEERING CO.	CHICAGO	IL	22376
K-T	K. T. ELECTRONICS CORP	JAPAN	**	NONE
KB-D	K B DENVER	FREDRICK	CO	57272
KDI-P	KDI-PYROFILM CORP.	WHIPPANY	NJ	03888
KEENE	KEENE CORP.	NEWARK	DE	52869
KEM	KEMTRON ELECTRON PRODUCTS	NEWBURYPORT	MA	92703
KEMET	KEMET ELECTRONICS CORP	GREENVILLE	SC	31433
KEY	KEYSTONE ELECTRONIC CORP.	NEW YORK	NY	91833
KIN	KINGS ELECTRONICS	TUCKAHOE	NY	91836
KMYO	KAMAYA INC	FORT WAYNE	IN	NONE
KOA	KOA SPEER ELECTRONICS	BRADFORD	PA	59124
KODAK	KODAK	ROCHESTER	NY	
KRSTL	KRISTEL CORP.	WEST CHICAGO	IL	NONE
KRYST	KRYSTINEL	PATERSON	NJ	29251
KSTR	KESTER SOLDER DIV.	CHICAGO	IL	09185
KSZI	KOSZEGI PRODUCTS,INC	SOUTH BEND	IN	NONE
KUL	KULKA ELECTRIC CORP.	MT. VERNON	NY	75382
KYCRA	KYOCERA INTERNATIONAL	SAN DIEGO	CA	59096
KYO	KYOCERA INTERNATIONAL INC., CERAMICS DIV.	SAN DIEGO	CA	59096
KYSOR	KEY SOURCE INTERNATIONAL	HAYWARD	CA	
L-E	LARSEN ELECTRONICS,INC.	VANCOUVER	WA	57202
L-ON	L-ON	DALLAS	TX	NONE
L-T	LINEAR TECHNOLOGY CORP.	MILPITAS	CA	64155
L.S	LEWIS SPRING	CHICAGO	IL	91314
LADU	LADEAU	LOS ANGELES	CA	NONE
LAMB	LAMB INDUSTRIES, INC.	PORTLAND	OR	65154
LAURN	LAUREN MFG CO.	NEW PHILADELPHIA	OH	56329
LED-T	LEADER TECHNOLOGY	LARGO	FL	4J674

ABBR.	NAME.....	CITY.....	ST	CAGE.
LEE	LEE SPRING CO.	DES PLAINES	IL	84830
LEYSE	LEYSE ALUMINUM CO.	KEWANEE	WI	20218
LIT	LITTELFUSE, INC.	DES PLAINES	IL	75915
LLC	LSI LOGIC	MILPITAS	CA	
LNMST	LINEMASTER SWITCH CORP.	WOODSTOCK	CT	97918
LOCTT	LOCTITE CORP.	NEWINGTON	CT	05972
LONCH	LONDON CHEMICAL			NONE
LRC	LRC ELECTRONICS, INC.	HORSEHEADS	NY	19644
LSI	LUMINESCENT SYSTEMS, INC	LEBANON	NH	32890
LTRNX	LITRONIX	CUPERTINO	CA	50579
LUMEX	LUMEX OPTO/COMPONENTS	PALATINE	IL	NONE
LYNIC	LYNICS CORP.	TOKYO	JA PA N	NONE
LYNTR	LYN-TRON INC.	BURBANK	CA	05791
LYTEL	LYTEL INCORPORTATED	SOMERVILLE	NJ	
M&G	M&G ELECTRONICS	HAUPPAUGE	NY	NONE
M-A	MICROWAVE ASSOCIATES	BURLINGTON	MA	96341
M-E	MEPCO ELECTRA, INC.	MORRISTOWN	NJ	19701
M-MAX	MIL-MAX MANUFACTURING CORP.	OYSTER BAY	NY	NONE
M-O	ILLUMINATED PRODUCTS INC.	SANTA ANA	CA	NONE
M-P	MICRO PLASTICS INC.	CHATSWORTH	CA	31223
M-P-C	METAL PROCESSING CO.	WOBURN	MA	NONE
M-TRN	M-TRON INDUSTRIES, INC	YANKTON	SD	23875
MACOM	M/A COM	BURLINGTON	MA	1HJ31
MAL	MALLORY CONTROLS CO.	FRANKFORT	IN	90201
MAL-C	MALLORY CAPACITOR COMPANY	INDIANAPOLIS	IN	7H877
MALIN	MALINKRODT			NONE
MAND	MANDEX	CHICAGO	IL	98278
MANEL	MANHATTAN ELECTRIC CABLE	RYE	NY	NONE
MARQ	MARQUARDT SWITCHES, INC.	CAZENOVIA	NY	7W718
MAX	MAXIM INTEGRATED PRODUCTS			NONE
MAYS	MAYS CHEMICAL CO, INC.	INDIANAPOLIS	IN	6T060
MCB	MCB MFG CHEMICALS			NONE
MCMD	MAC DERMID INC.	WATERBURY	CT	5E375
MCMTL	MICROMETALS, INC	ANAHEIM	CA	12856
MCRTK	MICROTEK COMPONENTS	SUN VALLEY	CA	NONE
MCS	MICRO POWER SYSTEMS INC.	SANTA CLARA	CA	54186
MD-AM	MID AMERICA	CHICAGO	IL	NONE
MDC	MAIDA DEVELOPMENT CO.	HAMPTON	VA	91984
MDLRS	MIDLAND ROSS	CINCINNATI	OH	57951
MDTC	MODUTEC	NORWALK	CT	32171
MEDLS	MEDALIST/RIEN LEITZKE	HUSTISFORD	WI	96652
METH	METHODE ELECTRONICS,INC.	ROLLING MEADOWS	IL	95354
METRA	METRA BYTE CORP.	TAUNTON	MA	
METRO	METRON OPTICS	SOLANA BEACH	CA	
MFLCO	MAURICE FRANKLIN LOUVER CO.	PROVIDENCE	RI	NONE
MGNCR	MAGNECRAFT ELECTRIC CO	NORTHBROOK	IL	94696
MGNUM	MAGNUM ELECTRIC CORP.	ERIE	MI	52458
MICCR	MICRO CARE CORP.	BRISTOL	CT	
MICLK	MICRO LINK	CARMEL	IN	58737
MICLN	MICRO LINEAR	SAN JOSE	CA	NONE
MICRO	MICRONEL	VISTA	CA	61655

ABBR.	NAME.....	CITY.....	ST	CAGE.
MILSD	MILITARY STANDARDS	WASHINGTON	DC	96906
MILSP	MILITARY SPECIFICATION	WASHINGTON	DC	81349
MILST	MILLER-STEPHENSON CHEM.	MORTON GROVE	IL	1DD67
MILT	MILTEX SALES CORP.	ELMHURST	IL	1BS53
MIN	MINOR RUBBER CO. INC.	BLOOMFIELD	NJ	76385
MIN-C	MINI-CIRCUITS	BROOKLYN	NY	15542
MINIS	MINI SYSTEMS	NORTH ATTLEBORO	MA	50316
MINOR	MINOR RUBBER CO.	BLOOMFIELD	NJ	76385
MIT	MITSUMI	TOKYO		NONE
MITEK	MITEK	LEXINGTON	MA	NONE
MLRJW	BELL INDUSTRIES INC / J W M ILLER	RANCHO DOMINGUEZ	CA	76493
MMC	MAGNUM MICROWAVE CORP.	MOUNTAIN VIEW	CA	1BD50
MMG	MMG	RICHARDSON	TX	
MMI	MONOLITHIC MEMORIES,INC.	SANTA CLARA	CA	50364
MMM	3M COMPANY	ST. PAUL	MN	NONE
MMR	M M REIF CO.,INC.	IVYLAND	PA	NONE
MNO	MONSANTO COMM. PROD. DIV.	PALO ALTO	CA	50522
MNTLN	MANTALINE CORP.	MANTUA	OH	4L685
MODPH	MODERN PHOTO			NONE
MOL	MOLEX PRODUCTS	LISLE	IL	27264
MORAD	MORGAN ADHESIVES	STOW	OH	17452
MOSTK	MOSTK CORP.	CARROLLTON	TX	50088
MOT	MOTOROLA SEMI. PROD. DIV.	INDIANAPOLIS	IN	04713
MOUS	MOUSER ELECTRONICS	LAKESIDE	CA	50811
MPC	MICROWAVE PRINTED CIRCUITRY	LOWELL,	MA	NONE
MPI	MICRO PLASTICS,INC.	FLIPPIN	AR	13764
MPUL	M-PULSE MICROWAVE	SAN JOSE	CA	
MRC	MATERIALS RESEARCH CORP.	BRIDGETON	MO	2P706
MRKMD	MARKING METHODS, INC.	ALHAMBRA	CA	18675
MRM	M. ROSS MASON	INDIANAPOLIS	IN	NONE
MRO	MICRO SWITCH DIV.	FREEPORT	IL	91929
MRODV	MICRO DEVICES DIV.	DAYTON	OH	27012
MRRUB	MARION RUBBER PROD.	INDIANAPOLIS	IN	NONE
MRSHL	MARSHALL INDUSTRIES	INDIANAPOLIS	IN	NONE
MSI	MSI ELECTRONICS,INC.	WOODSIDE	NY	5D618
MSN	MICROSONICS DIV.	WEYMOUTH	MA	11869
MSP	MICRO SEMICONDUCTOR CORP.	SANTA ANA	CA	14552
MTSBI	MITSUBISHI ELEC. CORP.	SUNNYVALE	CA	NONE
MUELR	MUELLER ELECTRIC CO.	CLEVELAND	OH	76545
MURA	MURA	WESTBURY	NY	32539
MURGA	MURATA-GEORGIA	MARIETTA	GA	51406
MWS	MAGNET WIRE SUPPLY CO.	CHATSWORTH	CA	51668
MWS-P	MWS PRECISION WIRE INDUS	WESTLAKE VILLAGE	CA	NONE
MXPI	VERSA/TEK CO/MOXNESS PRODUC TS INC	RACINE	WI	07099
N-T	NATIONAL TEL-TRONICS	LAREDO	TX	NONE
NARDA	NARDA MICROWAVE CORP.	HAUPPAUGE,L.I.	NY	99899
NASH	NASHUA CORP.	MERRIMACK	NH	
NAT	NATIONAL SEMICONDUCTOR CORP	SANTA CLARA	CA	27014
NCC	NATIONAL CERAMIC CO	TRENTON	NJ	76626

ABBR.	NAME.....	CITY.....	ST	CAGE.
NCM	NATIONAL CABLE MOLDING	LOS ANGELES	CA	
NCSVC	NATL COM SERV.	WILLOW GROVE	PA	NONE
NDK	NDK AMERICA,INC.	CUPERTINO	CA	
NDS	NATIONAL DECORATORS SUPPLY	INDIANAPOLIS	IN	8N392
NEC	NEC ELECTRONICS USA INC	MOUNTAIN VIEW	CA	4T165
NEL	NATIONAL ENGINEERING LABS	INDIANAPOLIS	IN	NONE
NELFC	NEL FREQUENCY CONTROLS,INC.	BURLINGTON	WI	
NEMC	NEW ENGLAND MICROWAVE	HUDSON	NH	3T103
NEMCO	NEMCO METALS, INC	MANVILLE	RI	9K312
NEW	NEWARK ELECTRONICS	INDIANAPOLIS	IN	NONE
NHBB	NEW HAMPSHIRE BALL BEARINGS INC	PETERBOROUGH	NH	83086
NHWC	NEW HAVEN WIRE & CABLE	NEW HAVEN	IN	NONE
NIC	NIC COMPONENTS CORP	FARMINGDALE	NY	NONE
NICHN	NICHICON (AMERICA) CORP.	SCHAUMBURG	IL	55680
NKK	NKK SWITCHES	SCOTTSDALE	AZ	
NMB	NMB CORP.	ARLINGTON HEIGHTS	IL	60005
NMG	NATIONAL MAGNETICS GROUP	NEWARK	NJ	
NOBLE	NOBLE U.S.A.,INC.	ELK GROVE VILLAGE	IL	NONE
NOVA	NOVACAP	BURBANK	CA	65238
NOVAT	NOVATION	CHATSWORTH	CA	4D778
NOYES	NOYES FIBER SYSTEMS	LaCONIA	NH	
NPC	NUCLEONIC PRODUCTS CO., THOMSON COMPONENTS, MOSTEK CORP., PASSIVE COMP. DIV.	WOODLAND HILLS	CA	NONE
NRTLK	NORTHLAKE ENG, INC	ANTIOCH	IL	50638
NSN	NATIONAL STOCK NUMBER			NONE
NTE	NTE SEMICONDUCTOR	BLOOMFIELD	NJ	
NTT	NATIONAL TEL-TRONICS	MEADVILLE	PA	91967
NYLO	NYLOMATIC	MORRISVILLE	PA	NONE
NYTCG	NYTRONICS COMPONENTS GROUP INC	DARLINGTON	SC	00213
O-S	OMNI SPECTRA INC.	FARMINGTON	MI	16179
OAK	OAK INDUSTRIES INC.	CRYSTAL LAKE	IL	76854
OHM	OHMITE MFG. CO.	SKOKIE	IL	44655
OKI	OKI SEMICONDUCTOR	SUNNYVALE	CA	
OKIDA	OKIDATA	MT LAUREL	NJ	
OLSON	OLSON TECHNOLOGY,INC.	SIERRA VILLAGE	CA	NONE
OMEGA	OMEGA WIRE & CABLE	HARLEYSVILLE	PA	NONE
OMRON	OMRON ELECTRONICS	SCHAUMBERG	IL	61964
OPTO	OPTO ELECTRONICS INC	FT LAUDERDALE	FL	3H278
OPTRN	OPTRON INC.	CARROLLTON	TX	32694
OPTRX	OPTREX	TOKYO	JA PA N	NONE
OTTIN	OTTINGER	ZIONSVILLE	IN	NONE
OXLEY	OXLEY INC.	BRANFORD	CT	3R006
P-B	POTTER AND BRUMFIELD	PRINCETON	IN	77342
P-C	POWER COMPONENTS	WOODLAND HILLS	CA	NONE
P-E	PAWLS ENGINEERING	XXXXX	XX	NONE
P-ONE	POWER-ONE, INC	CAMARILLO	CA	
P-T	PENN TUBE PLASTICS CO.	CLIFTON HEIGHTS	PA	NONE

ABBR.	NAME.....	CITY.....	ST	CAGE.
P-U	PROJECTS UNLIMITED INC.	DAYTON	OH	NONE
PACOM	PACCOM ELECTRONICS	REDMOND	WA	
PACTC	PACTEC DIV.	PHILADELPHIA	PA	NONE
PALCO	PALCO CONNECTOR INC	BRISTOL	CT	58167
PAM	PAMOTOR DIV.	BURLINGAME	CA	23936
PAND	PANDUIT CORP.	TINLEY PARK	IL	06383
PARA	PARAMETRIC INDUSTRIES	NORTHFIELD	IL	NONE
PARKR	PARKER SEAL GROUP	LEXINGTON	KY	NONE
PDI	POWER DYNAMICS,INC	WEST ORANGE	NJ	NONE
PEC	PACIFIC ELECTRICORD CO.	GARDENA	CA	80126
PEM	PENN ENGRG & MANUF CO.	DANBORO	PA	46384
PFZR	PFIZER,INC,	NEW YORK	NY	86491
PHC	PHILADELPHIA HANDLE CO.	CAMDEN	NJ	NONE
PHILP	PHILPOTT RUBBER CO.	CLEVELAND	OH	86510
PHLPS	PHILIPS CORPORATION/SIGNETICS	SUNNYVALE	CA	18324
PHRIN	PHREHIER INC	CHICAGO	IL	NONE
PIC	PIHER INTERNATIONAL CORP.	ARLINGTON HEIGHTS	IL	54869
PIEZO	PIEZO TECHNOLOGIES, INC.	ORLANDO	FL	25120
PIONR	PIONEER SCREW & NUT CO.	ELK GROVE VILLAGE	IL	NONE
PL-HI	POLY-HI	FORT WAYNE	IN	
PLI	PRECISION LAMP, INC.	MT. VIEW	CA	48451
PLSSY	PLESSEY ENG.	SCHILLER PARK	IL	55112
PLSTI	PLASTIC TECHNIQUES, INC	NEW BOSTON	NH	4P325
PLSTT	PLASTIC SYSTEMS, INC	MARLBORO	MA	NONE
PLYCL	POLYCLAD LAMINATES	SOUTHFIELD	MI	NONE
PMAS	PROBE MASTER	SAN DIEGO	CA	
PMCL	PERMACEL DIV.	NEW BRUNSWICK	NJ	99742
PMI	PRECISION MONOLITHICS INC.	SANTA CLARA	CA	06665
PNSNC	PANASONIC, PANASONIC INDL CO., ELEC COMP DIV	SEACAUCUS	NJ	54473
POLPH	POLYPHASE INSTR,CO	BRIDGEPORT	PA	98330
POLTR	POLYTRONIX	RICHARDSON	TX	NONE
POM	POMONA ELECTRONICS CO.,INC	POMONA	CA	05276
POSIT	POSITRONIC INDUSTRIES, INC	SPRINGFIELD	MO	
PP	PACIFIC POLYCRAFT			NONE
PPACK	POWER PACK INC	CHICAGO	IL	NONE
PREM	PREM MAGNETICS INC.	JOHNSBURG	IL	NONE
PREXT	PRECISION EXTRUSIONS, INC.	BENSENVILLE	IL	25379
PRMD	PYRAMID INDUSTRIES, INC.	PHOENIX	AZ	NONE
PROLG	PRO-LOG	MONTEREY	CA	55051
PRRES	PRECISION RESISTIVE PRDTS	MEDIAPOLIS	IA	60393
PRSN	PRECISION TUBE CO., INC	NORTH WALES	PA	82413
PTN	PENN TRAN CORP.	BELLEFONT	PA	NONE
PULSE	PULSE ENGINEERING	SAN DIEGO	CA	
PWRGP	POWER GROUP INTL.	BURNSVILLE	MN	25441
PWRMT	POWER-MATE CORP.	HACKENSACK	NJ	23934
PWRSN	POWER SONIC CORP.	REDWOOD CITY	CA	
PYRO	PYROFILM CORP.	WHIPPANY	NY	NONE
PYTT	PYTTRONICS INDUSTRIES, INC.	MONTGOMERYVILLE	PA	31924
Q-C	QUALITY COMPONENTS	ST. MARYS	PA	95121
QUAM	QUAM-NICHOLS CO.	CHICAGO	IL	74199

ABBR.	NAME.....	CITY.....	ST	CAGE.
R-B	RED BIRD			NONE
R-E	ROBISON ELECTRONICS	SAN LUIS OBISPO	CA	19080
R-G	REAGENT GRADE			NONE
R-N	ROBINSON-NUGENT	NEW ALBANY	IN	06776
R-OHM	R-OHM	IRVINE	CA	57668
RADL	RADIAL	STRATFORD	CT	NONE
RADTV	RADIO TV PROD CORP	DOUGLAS	AZ	
RAF	RAF ELECTRONIC HDWE	STRAFFORD	CT	NONE
RAWST	RAW STOCK	*****	**	NONE
RAY	RAYTHEON	INDIANAPOLIS	IN	49956
RAYVC	RAY-O-VAC/DV	MADISON	WI	3A440
RB	RISER-BOND	AURORA	NB	
RBRCT	RUBBERCRAFT CORP OF CALIFOR NIA	TORRENCE	CA	77969
RBYCN	RUBYCON	XXXXX	XX	NONE
RCA	RCA	CAMDEN	NJ	02735
RCD	RCD ELECTRONICS, INC	MANCHESTER	NH	56637
RCDSN	RICHARDSON ELECTRONICS	LAFOX	IL	
RCHLK	RICHLOK CORP	CHICAGO	IL	52238
RCL	RCL ELECTRONICS	HOLLYWOOD	FL	NONE
REHOF	REEVES HOFFMAN	CARLISLE	PA	NONE
REMTK	REMTEK	FREMONT	CA	59659
RENCO	RENCO ELECTRONICS INC	DEER PARK	NY	
RFPRI	RF PRIME	RANCHO CORDOVA	CA	
RGNCY	REGENCY ELECTRONICS, INC.	INDIANAPOLIS	IN	06518
RGR	ROGERS CORP.	CHANDLER	AZ	31745
RICH	RICHCO PLASTIC CO.	CHICAGO	IL	06915
RICHM	RICHARDS METAL PRODUCTS	WOLCOTT	CT	19076
RMC	RADIO MATERIALS CORP.	CHICAGO	IL	82560
RMF	RMF PRODUCTS INC.	BATAVIA	IL	NONE
RMS	RMS ELECTRONICS,INC.	BRONX	NY	3L197
ROBNU	ROBINSON NUGENT, INC.	NEW ALBANY	IN	06776
ROCKW	ROCKWELL INTL.	ANAHEIM	CA	33085
ROGAN	ROGAN CORP.	NORTHBROOK	IL	86797
ROHM	ROHM	IRVINE	CA	57668
ROTRN	ROTRON INC.	WOODSTOCK	NY	82877
RPBLC	REPUBLIC ELECTRONICS CORP	PATTERSON	NJ	93958
RSSLL	RUSSELL	OCEANSIDE	NY	24324
RTNA	ROSENTHAL TECHNIK,N.A.	PROVIDENCE	RI	NONE
RXD	RXD, INC.	NORFOLK	NE	NONE
RYCHM	RAYCHEM	MENLO PARK	CA	NONE
RYRSN	RYERSON	CHICAGO	IL	
S-C	SPECIALTY CONNECTOR	INDIANAPOLIS	IN	24931
S-G	STANDARD GRIGSBY	AURORA	IL	82104
S-I	SWITCHCRAFT, INC.	CHICAGO	IL	82389
S-S	SERVICE SUPPLY	INDIANAPOLIS	IN	08323
S-T	SARKES TARZIAN	BLOOMINGTON	IN	51589
S-W	SOUTH WALL	PALO ALTO	CA	NONE
SAE	STANFORD APPLIED ENG	SANTA CLARA	CA	6E609
SAFT	SAFT AMERICA	COCKEYSVILLE	MD	31586
SAGE	SAGE LABORATORIES, INC.	NATIC	MA	07180

ABBR.	NAME.....	CITY.....	ST	CAGE.
SAHA	SUSCO ELECTRONICS	FARMINGDALE	NY	NONE
SANYO	SANYO ELECTRIC, INC.	LITTLE FERRY	NJ	NONE
SAROX	SARONIX	PALO ALTO	CA	61441
SAVOY	SAVOY ELECTRONICS, INC.	FT. LAUDERDALE	FL	13075
SCBE	SCANBE DIVISION	EL MONTE	CA	18677
SCC	STACKPOLE CARBON CO.	ST. MARYS	PA	78488
SCCHM	SOUTHERN CALIFORNIA CHEMICAL CO., INC.	GARLAND	TX	54507
SCHRF	SCHROFF,INC	WARWICK	RI	62559
SCHRT	SCHURTER, INC.	PETALUMA	CA	61935
SCI	SEMICONDUCTOR CIRCUITS INC	WINDHAM	NH	
SCS	STEWART CONNECTOR SYSTEMS	GLEN ROCK	PA	
SCX	SILICONIX INC.	SANTA CLARA	CA	17856
SDI	SDI INC	NORTH BILLERICA	MA	54558
SEAST	SEASTROM MFG. CO.	GLENDALE	CA	86928
SECR	SEACOR	WESTWOOD	NJ	53332
SEIKO	SEIKO INSTRUMENTS		JAPAN	NONE
SEITZ	SEITZ SONS,INC.	TORRINGTON	CT	NONE
SEL	SEALECTRO CORP.	MAMARONECK	NY	98291
SEM	SEMTECH	NEWBURY PARK	CA	14099
SEMI	SEMICONDUCTORS INC.	RIVIERA BEACH	FL	6T663
SEMTX	SEMTEX	DAYTON	OH	NONE
SERRA	SIERRA SEMICONDUCTOR	SAN JOSE	CA	
SGM	SIGMA INSTRUMENTS	BRAINTREE	MA	72421
SGS-A	SGS-ATES COMP ELET SPA	AGRATE BRIANZE, ITALY	**	NONE
SHAM	SHAMROCK PLASTICS & RUBBER	INDIANAPOLIS	IN	NONE
SHARP	SHARP ELECTRONICS CORP.	MAHWAH	NJ	
SHDW	I.T.T. SCHADOW	EDEN PRAIRIE	MN	NONE
SHGYO	SHOGYO INTERNATIONAL CORP	GREAT NECK	NY	NONE
SHIN	SHIN-ETSU POLYMER CO.LTD.	*	*	NONE
SHIP	SHIPLEY CO, INC.	NEWTON	MA	21079
SHKMN	SHACKMAN INSTRUMENTS	CHESHAM, ENGLAND	**	NONE
SHKPF	SHAKEPROOF DIV,ILLINOIS TOOL WORKS	ELGIN	IL	78189
SHURE	SHURE BROS, INC.	EVANSTON	IL	45715
SIECO	SIECOR	HICKORY	NC	
SIEM	SIEMENS	ISELIN	NJ	25088
SIERR	SIERRACIN POWER SYSTEMS	CHATSWORTH	CA	58999
SIG	SIGNETICS CORPORATION	SUNNYVALE	CA	18324
SIGNL	SIGNAL TRANSFORMER	INWOOD	NY	NONE
SIGPT	SIGMA PLASTRONICS	DEARBORN	MI	NONE
SIMP	SIMPSON ELECTRIC COMPANY	ELGIN	IL	2X624
SINCR	SINCLAIR & RUSH, INC.	ST. LOUIS	MO	15819
SINRA	SINCLAIR RADIO LABORATORIES,INC.	TONAWANDA	NY	
SKDRV	STOCK DRIVE PROD. DIV.	NEW HYDE PARK	NY	6F689
SLCGN	SILICON GENERAL INC	GARDEN GROVE	CA	34333
SLT	SOLITRON/MICROWAVE DIV.	PORT SALERNO	FL	95077
SMILY	SMILEY ANTENNA CO.,INC.	EL CAJUN	CA	
SMOR	SMOR CASES,INC.	SOUTH BEND	IN	

ABBR.	NAME.....	CITY.....	ST	CAGE.
SMOS	S-MOS SYSTEMS, INC.	SAN JOSE	CA	NONE
SMSNG	SAMSUNG SEMICONDUCTOR	SANTA CLARA	CA	NONE
SMTC	SAMTEC INC.	NEW ALBANY	IN	55322
SNGMO	SANGAMO CAPACITOR DIV	PICKENS	SC	00853
SNSTK	SENSOR TECHNOLOGY CO	SEATTLE	WA	29927
SOART	STATE OF THE ART, INC	STATE COLLEGE	PA	56235
SONY	SONY		JA PA N	NONE
SOUCA	SOUTHERN CALIFORNIA			NONE
SOUR	SOURIAU INC	VALENCIA	CA	
SOURU	SOURIAU	VAN NUYS	CA	4R752
SOUTH	SOUTHCO FASTENERS	LESTER	PA	94222
SPE	SPECTROL ELECTRONICS	CITY OF INDUSTRY	CA	02111
SPEC	SPECTRUM CONTROL. INC.	FAIRVIEW	PA	33095
SPELE	SPECIALTY ELECTRONIC, INC.	LANDRUM	SC	
SPI	SEMI PROCESSES INC.	SAN JOSE	CA	61837
SPNPD	SPENDER PRODUCTS	FT. WAYNE	IN	NONE
SPPRD	SPECIALTY PRODUCTS	INDIANAPOLIS	IN	NONE
SPR	SPRAGUE ELECTRIC CO.	INDIANAPOLIS	IN	56289
SPR-G	SPRAGUE - GOODMAN	GARDEN CITY PARK	NY	
SPRTX	SUPERTEX INC.	CUPERTINO	CA	59640
SPS	SPS TECHNOLOGIES (UNBRAKO D IV)	JENKINTOWN	PA	50394
SPST	SPECTRA-STRIP	GARDEN GROVE	CA	08261
SPY	SPYRAFLO INC	PEACHTREE CITY	GA	13603
SSS	SOLID STATE SCIENTIFIC	MONTGOMERYVILLE	PA	31019
STAR	STAR	NEW YORK	NY	
STAV	STAVER	BAY SHORE	NY	04232
STC	SILICON TRANSISTOR CORP	CHELMSFORD	MA	07256
STI	SEMICNDTR TECHNOLOGY INC	STUART	FL	3R318
STKFS	STAKE FASTENERS	SOUTH EL MONTE	CA	NONE
STNCR	STANCOR PRODUCTS	LOGANSPORT	IN	NONE
STNDX	STANDEX	CINCINNATI	OH	NONE
STOCK	STOCK DRIVE PRODUCTS	NEW HYDE PARK	NY	
STR	STETTNER TRUSH CO.	CAZENOVIA	NY	52763
STRCO	STRANCO PRODUCTS,INC.	ELK GROVE VILLAGE	IL	04160
STSA	STEEL SALES	INDIANAPOLIS	IN	NONE
STSND	STAR SOUND	JAPAN	**	NONE
SULL	SULLINS ELECTRONICS CORP	SAN MARCOS	CA	54453
SWMIN	SWIDGET MINIATURE	WARMINSTER	PA	NONE
SXNBG	SAXONBURG CERAMICS	SAXONBURG	PA	14119
SYL	GTE SYLVANIA	WALTHAM	MA	94131
SYN	SYNTRONIC INSTRUMENTS	ADDISON	IL	99409
SYNRG	SYNERGY MICROWAVE CORP.	JERSEY CITY	NJ	NONE
SYNTC	SYNTAC CORP.	CLEVELAND	OH	NONE
SYNTK	SYNERTEK	**	*	NONE
SYS	SYSCON INTERNATIONAL, INC.	SOUTH BEND	IN	32436
T-B	THOMAS & BETTS	RARITAN	NJ	59730
T-CSF	THOMSON-CSF COMPONENTS CORP .	RUTHERFORD	NJ	62744
T-I	TEXAS INSTRUMENTS	DALLAS	TX	01295
TAIYO	TAIYO YODEN C/O COMPONENTS IMPORTS,INC.	SCHAUMBURG	IL	NONE

ABBR.	NAME.....	CITY.....	ST	CAGE.
TAMUR	TAMURA CORP. OF AMERICA	CARSON	CA	
TANDY	TANDY CORP.	FORT WORTH	TX	NONE
TAPP	TAPE PRODUCTS, INC	*****	**	NONE
TCPL	TACONIC PLASTIC	PETERSBURG	NY	59688
TDI	TELECOMMUNICATIONS DEVICES	DOWNERS GROVE	IL	NONE
TDK	TDK CORPORATION OF AMERICA	PROSPECT	IL	NONE
TECMA	TECMA	EL PASO	TX	
TEK	TEKTRONIX	INDIANAPOLIS	IN	80009
TEKA	TEKA PRODUCTS INC.	COLLEGE POINT	NY	58050
TEKMD	TEKMOLD,INC.	MUSKEGON	MI	NONE
TEKNT	TECKNIT	CRANSFORD	NJ	07700
TELCM	TELECOMMUNICATION PRODUCTS CORP.	CHAMBERSBURG	PA	
TELE	TELETYPE CORP.	ELK GROVE VILLAGE	IL	NONE
TELEX	TELEX COMMUNCATIONS,INC.	MINNEAPOLIS	MN	28856
TELRY	TELEDYNE RELAYS	HAWTHORNE	CA	11532
TELSM	TELEDYNE SEMICONDUCTOR	MOUNTAIN VIEW	CA	15818
TETCH	TECH-ETCH,INC.	PLYMOUTH	MA	
TFI	T&F INDUSTRIES DIV.	ROLLING MEADOWS	IL	58933
TFL	TFL	MITCHEL FIELD	NY	
THMET	THERMOMETRICS	EDISON	NJ	
THMST	THERMOSET	INDIANAPOLIS	IN	22156
THOMN	THOMSON INDUSTRIES INC.	PORT WASHINGTON	NY	96881
THR	THERMALLOY CO.	DALLAS	TX	13103
TIMES	TIMES WIRE AND CABLE	CINCINNAI	OH	07145
TIN	TINNERMAN PRODUCTS, INC.	CLEVELAND	OH	78553
TKN	TECHNICAL WIRE	CRAWFORD	NJ	07700
TLLAB	TEL LABS,INC	LONDONDERRY	NH	94322
TLNC	TELONIC ALTAIR	LAGUNA BEACH	CA	04423
TLSBY	TILSBY	*****	**	NONE
TMSTR	TONE MASTER ELEC.CO.	PEORIA	IL	
TOCOS	TOCOS AMERICA, INC.	ARLINGTON HEIGHTS	IL	NONE
TOKO	TOKO AMERICA	SKOKIE	IL	NONE
TORIN	NIDEC-TORIN CORP.	TORRINGTON	CN	67088
TOWER	TOWER MFG. CORP.	PROVIDENCE	RI	87930
TOYO	TOYO COMMUNICATION CO.	TOKYO,JAPAN	**	NONE
TR-UT	TRIAD-UTRAD DIV.	HUNTINGTON	IN	NONE
TRIPP	TRIPPLITE	CHICAGO	IL	
TRITH	TRILITHIC	INDIANAPOLIS	IN	NONE
TRIYX	TRIONYX INDUSTRIES	INDIANAPOLIS	IN	NONE
TRNSN	TRANSENE CO., INC.	ROWLEY	MA	53796
TRU	WALDES TRUARC	LONG ISLAND CITY	NY	79136
TRW	TRW CAPACITOR DIV.	OGALLALA	NB	84411
TRWLL	TRI-WALL CONTAINERS,INC.	WOODBURY	NY	13351
TRX	TRX CORPORATION	ATTLEBORO FALLS	MA	NONE
TSHBA	TOSHIBA AMERICA INC	WAYNE	NJ	NONE
TTC	TRAN-TEC CORP.	COLUMBUS	NB	50934
TUSNX	TUSONIX, INC.	TUCSON	AZ	59660
TWAY	TWAY COMPANY	INDIANAPOLIS	IN	NONE
TXL	TEXEL COMPONETS	AUSTIN	TX	61743
TXSLS	TX SALES	FORT WAYNE	IN	NONE
TYTON	TYTON CORP.	MILWAUKEE	WI	3E655
ULSP	UNDERWRITERS LAB. SPEC.	CHICAGO	IL	NONE

ABBR.	NAME.....	CITY.....	ST	CAGE.
UNAOH	UNAOHM	MILANO, ITALY	**	
UNCBL	UNICABLE,INC.	BRIDGEPORT	CT	NONE
UNCHM	UNITED CHEMI-CON INC.	ROSEMONT	IL	62643
UNIC	UNICORP	ORANGE	NJ	04729
UNIT	UNITRODE CORP.	WATERTOWN	MA	12969
UNIV	UNIVERSAL SEMICONDUCTOR INC	SAN JOSE	CA	NONE
USECO	USECO DIV.	VAN NUYS	CA	88245
USMFS	USM FASTENER DIV.	SHELTON	CT	07707
UTK	UNITRACK DIV.	UPPER DARBY	PA	07556
VAC	VACTEC INC.	MARYLAND HEIGHTS	MO	18178
VACO	VACO PRODUCTS CO.	NORTHBROOK	IL	79061
VAR	VARADYNE CAPACITOR DIV.	SANTA MONICA	CA	26654
VARIL	VARI-L CO.	DENVER	CO	05375
VARO	VARO SEMICONDUCTOR INC	GARLAND	TX	62703
VAULT	VAULT CORP	WESTLAKE VILLAGE	CA	NONE
VCTRN	VECTRON LABORATORIES,INC.	NORWALK	CT	27802
VEC	VICTORY ENGINEERING CORP.	SPRINGFIELD	NJ	83186
VELCR	VELCRO USA INC	NEW YORK	NY	11153
VIC	VICTOREEN INC	CLEVELAND	OH	7X287
VIK	VIKING CONNECTORS	CHATSWORTH	CA	8W949
VIN	VINCENT BRASS AND ALUM. CO.	INDIANAPOLIS	IN	9N280
VISCM	VISUAL COMM	PLAYA DEL REY	CA	56769
VLSI	VLSI TECHNOLOGY,INC	SAN JOSE	CA	66302
VLTRX	VOLTREX	CHICAGO	IL	02929
VONGT	VONNEGUT HARDWARE	INDIANAPOLIS	IN	NONE
VRN	VERNITRON CORP.	ST. PETERSBURG	FL	84048
VRW	VAN WATERS AND RODGER	INDIANAPOLIS	IN	NONE
VSSNC	VIEWSONICS, INC.	SYOSSET	NY	59108
VTRMN	VITRAMON, INC.	BRIDGEPORT	CT	95275
W-E	WELLS ELECTRONICS	SOUTH BEND	IN	14329
W-GMB	WAVETEK GERMANY	GERMANY	**	
W-I	WAVETEK INDIANA, INC.	BEECH GROVE	IN	34280
W-PMI	WAVETEK PACIFIC MEASUREMENTS	SUNNYVALE	CA	28821
WAG	WAGNER ELECTRIC CORP.	ST. LOUIS	MO	63477
WALBN	WALBURN DEVICES, INC.	LINDEN	NJ	5K273
WAMCO	WAMCO, INC.	FOUNTAIN VALLEY	CA	58774
WBSH	WABASH RELAY & ELECT.	WABASH	IN	18542
WDI-P	WESTERN DIGITAL IMAGING/PARADISE	MOUTAIN VIEW	CA	
WECK	WECKESSER CO., INC.	CHICAGO	IL	95987
WESCO	WESCO ELECTRONICS	LOS ANGELES	CA	14551
WESGD	WES-GRADE COMP.GROUP,INC	WESTERVILLE	OH	
WHBRY	W.H.BRADY INDL PRDS DIV	MILWAUKEE	WI	1AA96
WHTMN	WHITMAN	CINCINNATI	OH	NONE
WILCO	WILCO CORP.	INDIANAPOLIS	IN	99848
WIMA	WILHELM WESTERMANN	MANNHIEM	GERMANY	
WIN	WINCHESTER ELECTRONICS	OAKVILLE	CT	81312
WKFLD	WAKEFIELD ENGINEERING	WAKEFIELD	MA	05820
WLDM	WALDOM	CHICAGO	IL	92219
WLG	W.L. GORE	NEWARK	DE	17217

ABBR.	NAME.....	CITY.....	ST	CAGE.
WMBG	W.M. BERG	ROCKAWAY	NY	29449
WNSL	WEINSCHEL ENGINEERING	GAITHERSBURG	MD	93459
WRC	WIRE RESEARCH CORP	SANTA ANA	CA	NONE
WRGPA	W. R. GRACE AND CO. POLYFIBRON DIV.	ROANOKE RAPIDS	NC	53718
WSD	WAVETEK	SAN DIEGO	CA	23338
WSTLK	WESTLAKE CAPACITORS INC	GREENCASTLE	IN	60935
WSTN	WESTON COMPONENTS	ARCHBALD	PA	94075
X-MRO	X-MICRO			NONE
XICOR	XICOR, INC.	MILPITAS	CA	60395
YORK	YORK INDUSTRIES	GARDEN CITY PARK	NY	1P678
YUASA	YUASA BATTERY CO,LTD	MINATO-KU	TOYKO, JAPAN	
Z-COM	Z-COMMUNICATIONS,INC.	FT.LAUDERDALE	FL	NONE
ZELL	ZELLERBACH/MEAD MERCHANTS CO.	INDIANAPOLIS	IN	
ZEN	ZENITH RADIO CORP.	CHICAGO	IL	67177
ZERO	ZERO MANUFACTURING CO.	BURBANK	CA	98376
ZIE	ZIERICK MFG. CORP.	MOUNT KISCO	NY	79963
ZPT	ZIPPERTUBING, CO.	LOS ANGELES	CA	07240

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
7	THUMB NUT,#4-40, NICKEL,3/8"D X 1/4"H	75001-NP	F-S	2810-16-0037	6.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
1	BACK FEET, 2407 FROM:3210-03-0047	1410-30-8870	W-I	1410-30-8870	2.000
2	OUTER COVER,2407 FROM:3210-02-0589	1410-80-2540	W-I	1410-80-2540	1.000
3	SCW,PPH,8-32 X3/4	19068NP	F-S	2810-55-8112	4.000
4	SEMS-PPH-INT 6-32 X 5/16 NP	PER DESC2810-57-6105	F-S	2810-57-6105	8.000
5	SEMS-PPH-INT 4-40X3/16,BK ZINC	PER DESC2810-58-4103	F-S	2810-58-4103	6.000
8	EXTENSION SPRING, 2407,SPC PER PRINT	1410-01-5235	W-I	1410-01-5235	3.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
2	ENCLOSURE HANDLE, 24XX & 24XXR	1410-30-8900	W-I	1410-30-8900	2.000
3	GUIDE PIN .150 O.D.	1410-30-8910	W-I	1410-30-8910	2.000
4	FRONT END CAP,LO/ REF & REF SYNTH, FROM:3210-02-0025	1410-60-4279	W-I	1410-60-4279	1.000
5	REAR ENCLOSURE END CAP,2407	1410-60-4120	W-I	1410-60-4120	1.000
6	REAR ENCLOSURE GASKET,2407	1410-60-4180	W-I	1410-60-4180	1.000
7	FRONT ENCLOSURE GASKET,2407	1410-60-4190	W-I	1410-60-4190	1.000
8	RF ENCLOSURE WITH CENTER WALL,24XX FROM:3210-06-0051	1410-80-2590	W-I	1410-80-2590	1.000
9	SCREW 4-40X1/4" PPH THREAD CUTTING,TYPE1 ZINC PLATED	2810-22-0008	ANY	2810-22-0008	14.000
10	SCW,82 PFUCUT, 4-40X3/16	PER DESC2810-23-0091	F-S	2810-23-0091	6.000
11	SEMS-PPH-INT 4-40 X 3/8 NPPER B/P	PER DESC2810-57-4106	F-S	2810-57-4106	4.000
12	NUT 3/8 ACROSS FLATS .250-36 THREAD	2810-16-0030	F-S	2810-16-0030	5.000
13	I,LW,1/4X.408X.018 HW102-000	30-120	F-S	2810-28-0001	5.000
14	(C)WASHER,.255X7/16	97017	F-S	2810-26-0004	5.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
2	SHIELD,REF &LO BD	1410-60-4282	W-I	1410-60-4282	1.000
3	MICA INSULATOR	B08853A001	MOT	2810-11-0004	1.000
4	SHLDR WSHR,NYLON INSULATING BUSHING, TO-220	B51547F019	MOT	2810-11-0031	1.000
5	NUT,4-40,HN101-400	8002A-NP	F-S	2810-14-4100	3.000
6	LOCK WASHER,NO.4 CRES.INT.STARSTNLS.	99402	F-S	2810-28-0047	3.000
7	SCW,PPH,4-40X1/4	19022NP	F-S	2810-55-4104	3.000
C601 C603	CAP,CER,.22uF,50V 10%,AXL,X7R .14"Dx.39"L	592CZ5U224M050D	SPR	1510-16-5224	2.000
C602 C604 C605 C606 C610 C612 C613 C615 C616 C623 C624 C640 C651 C658 C659 C660 C661 C662 C663 C664 C665 C666 C667 C668 C669 C670 C671 C672 C673 C674 C676	CAP,CER,.1uF,50V 20%,AXL,Z5U .10"Dx.26"L	SA205E1042AA	AVX	1510-17-1104	31.000
C607 C608 C609 C642 C646	CAP,CER,1000pF,50V 10%,AXL,X7R .09"Dx.16"L	RPA10X7R102K50VPT	MURGA	1510-16-8102	5.000
C617 C618 C619 C620 C621 C622 C678 C680	CAP,TNT,1µF,25V 10%,AXL.095"Dx.260"L	173D105X9025U	SPR	1510-21-7010	8.000
C652	CAP,VAR,2.5-5PF	302504111	STR	1510-70-8509	1.000
C675	100 PF 20% 100V NPO AXIAL LEAD,TAPE/REEL	C410C101M1G5CA	KEM	1510-17-1101	1.000
C677	CAP,CER,.01uF,50V 10%,AXL,X7R .10"Dx.17"L	SA105C103KAA	AVX	1510-17-1103	1.000
C679	CAP,TNT,3.3UF,25V, 10%,AXL,.110X.290	T322B335K025AS	KEM	1510-21-7339	1.000
CR601 CR603 CR604	DIODE,SIGNAL,GP AXIAL,V=75V,IO=10mA CT=4pF,*SS*	1N914	G-E	4807-01-0914	3.000
CR602	DIODE,ZENER,500mW,GP DO-35,V=5.1,IT=20mA IF=89mA,+/-20%,*SS*	1N5231	MOT	4801-01-5231	1.000
CR606 CR607	DIODE,PIN,GP SWIT AXIAL,V=100V CT=0.4pF,*SS*	5082-3080	H-P	4805-02-0002	2.000
IC601	PLL FRQ SYN,D BUS IN PLAS,DIP-20,CMOS*SS*	MC145146P1	MOT	8014-51-4610	1.000
IC602	LO-PWR PRESCALER DIVIDE BY 64,PLAS DIP-8,MECL *SS*	MC12073P	MOT	8001-20-7310	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
IC603 IC604	OCT 3-STATE NON-INV D-TYPE FLIP-FLOP*SS* PLASTIC,DIP-20 CMOS	MC74HC574N	MOT	8007-45-7410	2.000
IC605 IC614	UWAVE WB AMP,0204*SS*	MSA-0204	AVT	4902-00-2040	2.000
IC606	BUFFER,OCTAL,3 STATE PLAS,DIP-20,*SS* HIGH SPEED CMOS	MC74HC541N	MOT	8007-45-4110	1.000
IC607	DCDR/DEMUX,1-OF-8 PLAS,DIP-16 H SPD CMOS,*SS*	MC74HC138N	MOT	8007-41-3811	1.000
IC608 IC612	OP AMP,JFET INPUT PLAS,DIP-8,18Vdc 13V/uS,*SS*	TL082CP	T-I	7000-00-8200	2.000
IC609	POS. VOLT REG-3 TERM PLAS,TO-220AB,5 VOLT 500mA,7 W,5%,3-TERM	UA78M05CKC	T-I	7000-78-0500	1.000
IC610	VOLT REG,FIXED,+15V PLAS,3 PIN(TO-220) 35Vdc,.1%,700mA,*SS*	LM78M15CT	NAT	7000-78-1500	1.000
IC611	VOLT REG,-15V,3-TERM PLAS,TO-220,35Vdc 5%,1.5W,1.0A	UA79M15CKC	T-I	7000-79-1500	1.000
IC613	UWAVE WB AMP,0404*SS*	MSA-0404	AVT	4902-00-4040	1.000
J602 J603 J604	CONN,SMA-F,50,PC MT RT ANG	42-302-1	CNTRS	2110-02-0017	3.000
L601 L603 L604	CHOKE,COATED,1UH,10% D=0.120IN,L=0.300IN, I=385MA	08N1R0	JEF	1810-03-0010	3.000
L605 L606 L607 L608 L609	CHOKE,COATED,39UH 10%,D=0.120IN, L=0.300,I=125MA	09C390K	JEF	1810-03-0390	5.000
P601	D-CONN,FILTERED,37 PIN,RT ANGLE,MALE, 500 PF	FDX37M5R7NOX	POSIT	2112-04-0024	1.000
Q607 Q608	NPN,TO-92,GP AMP/SW F=300,V-40,Icex=50nA P=625mW,hFE=100,*SS*	2N3904	NAT	4901-03-9040	2.000
Q609	PNP,TO-39,SWITCH,V=4 0V,PD=1W,IC=1A,HFE40 -120,FT=150,VCE,=0.3	2N3467	MOT	4901-03-4670	1.000
Q610	PNP,TO-18,GP SW,AMP, FT=200,V=40,P=0.4W, HFE=300 MAX,IC=600	2N2907	MOT	4901-02-9070	1.000
R600 R602 R603 R604 R605 R632 R633 R637 R638	(P)RES,MF,10K,1% 1/4W,AXL,TC=100ppmT/R	MF55D1002FL	KOA	4701-03-1002	9.000
R601 R634 R635 R636 R654 R662	(P)RES,MF,1K,1% 1/4W,AXL,TC=100ppmT/R	MF55D1001FL	KOA	4701-03-1001	6.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
R606 R607 R611	(S)RES,MF,3.65K,1% 1/4W,AXL,TC=100ppmT/R	MF55D3651FL	KOA	4701-03-3651	3.000
R608	(S)RES,MF,1.18K,1% 1/4W,AXL,TC=100ppmT/R	MF55D1181FL	KOA	4701-03-1181	1.000
R609 R610	(P)RES,MF,12.1K,1% 1/4W,AXL,TC=100ppmT/R	MF55D1212FL	KOA	4701-03-1212	2.000
R612 R642 R643 R644 R658	(S)RES,MF,475,1% 1/4W,AXL,TC=100ppmT/R	MF55D4750FL	KOA	4701-03-4750	5.000
R639 R641	(P)RES,MF,150,1% 1/4W,AXL,TC=100ppmT/R	MF55D1500FL	KOA	4701-03-1500	2.000
R640	(S)RES,MF,37.4,1% 1/4W,AXL,TC=100ppmT/R	MF55D3749FL	KOA	4701-03-3749	1.000
R645 R647 R651	(S)RES,MF,95.3,1% 1/4W,AXL,TC=100ppmT/R	MF55D9539FL	KOA	4701-03-9539	3.000
R646	(S)RES,MF,68.1,1% 1/4W,AXL,TC=100ppmT/R	MF55D6819FL	KOA	4701-03-6819	1.000
R648 R650	(S)RES,MF,301,1% 1/4W,AXL,TC=100ppmT/R	MF55D3010FL	KOA	4701-03-3010	2.000
R649	(S)RES,MF,18.2,1% 1/4W,AXL,TC=100ppmT/R	MF55D1829FL	KOA	4701-03-1829	1.000
R652	(P)RES,MF,8.25K,1% 1/4W,AXL,TC=100ppmT/R	MF55D8251FL	KOA	4701-03-8251	1.000
R653	(S)RES,MF,200,1% 1/4W,AXL,TC=100ppmT/R	MF55D2000FL	KOA	4701-03-2000	1.000
R655	(S)RES,MF,392,1% 1/4W,AXL,TC=100ppmT/R	MF55D3920FL	KOA	4701-03-3920	1.000
R656 R657 R659 R660 R661	(S)RES,MF,5.11K,1% 1/4W,AXL,TC=100ppmT/R	MF55D5111FL	KOA	4701-03-5111	5.000
Y601	TCXO,10 MHZ,5V FOR 2520, *SS*	TCO-909-10.00000	TOYO	2311-00-0018	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
1	PC BOARD,LO/REF,2410A	1710-30-0150	W-I	1710-30-0150	1.000
C644 C650 C655 C657	(P)CAP,CER,.001uF 100V,20%,CHP,X7R 0805,T/R,VALUE MARKD	08051C102MAT050M	AVX	1510-06-7102	4.000
C647 C648	(P)CAP,CER,15PF,50V 1%,CHIP,NPO,+/-30PPM 0805,T/R,VALUE MARKD	C2012COG1H150FT	TDK	1510-06-5150	2.000
C649 C656	CAP,TANT,10 UF,25V SURFACE MOUNT,T/R	NRD106M25R12	NEC	1510-27-9106	2.000
C653	(S)CAP,HI-Q,20pF 50V,+/-1%,CHP,P90 20ppm,0505,T/R	500R12Q200FV5P	JHSN	1510-06-3200	1.000
C654	(S)CAP,HI-Q,15pF 50V,+/-1%,CHP,P90 20ppm,0505,T/R	500R12Q150FV5P	JHSN	1510-06-3150	1.000
CR605	DIODE,VAR CAP,*SS* SOT-23,Ct=1.8pF,V=28 T/R	BBY31 (SOT-23) T/R	APX	4807-02-0005	1.000
Q601 Q604 Q605	PNP,SOT-23,MED PWR F=200m,V=40,P=350m, hFE=40,*SS*,T/R	BSR18A-TRL	APX	4902-00-0800	3.000
Q603	NPN,SIL,H FRQ,TRAN SOT-23,fT-8GHz, *SS*,T/R	NE68133-T1B	NEC	4902-68-1330	1.000
Q606	NPN,SOT-23,MED PWR F=250m,V=40,P=310m, hFE=40,*SS*,T/R	BSS79CE6237	SIEM	4902-00-0170	1.000
R617 R625 R627	RES,CHP,243,1% 1/8W,TC=100ppm,T/R 1206 CASE	RMC1824391C	KMYO	4711-03-2430	3.000
R618 R622 R626	RES,CHP,576,1% 1/8W,TC=100ppm,T/R 1206	RMC1857691C	KMYO	4711-03-5760	3.000
R619 R623 R624	(P)RES,CHP,10.0,1% 1/8W,TC=100ppm,T/R 1206	RMC1810081C	KMYO	4711-03-1009	3.000
R620	RES,CHP,37.4,1% 1/8W,TC=100ppm,T/R 1206	RMC1837481C	KMYO	4711-03-3749	1.000
R628 R629	(P)RES,CHP,10.0K,1% 1/8W,TC=100ppm,T/R 1206	RMC1810021C	KMYO	4711-03-1002	2.000
R630 R631	(S)RES,CHP,2.67K,1% 1/8W,TC=100ppm T/R 1206 CASE	RMC1826711C	KMYO	4711-03-2671	2.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
1	PCB,REF SYNTH,2410A	1710-30-0145	W-I	1710-30-0145	1.000
2	BOTTOM SHIELD REF/ SYNTH FROM:3210-01-0034	1410-60-4280	W-I	1410-60-4280	1.000
3	SHIELD,TOP,REF/SYNTH FROM:3210-01-0034	1410-60-4281	W-I	1410-60-4281	1.000
C1504 C1509 C1514 C1515 C1523 C1524 C1525 C1529 C1530 C1531 C1534 C1537 C1538 C1544 C1545 C1546 C1547 C1563 C1566 C1568 C1570 C1571 C1573 C1576 C1577 C1578	CAP,CER,.1uF,50V 20%,AXL,Z5U .10"Dx.26"L	SA205E1042AA	AVX	1510-17-1104	26.000
C1519 C1520 C1521 C1522 C1532 C1541 C1542 C1561 C1574 C1575	CAP,TNT,1uF,25V 10%,AXL.095"Dx.260"L	173D105X9025U	SPR	1510-21-7010	10.000
C1535 C1536	CAP,CER,.047uF,50V, 10%,AXL,X7R,T/R, .1"Dx.17"L	SA205C473KAA	AVX	1510-17-1473	2.000
C1539 C1540	CAP,CER,4.7uF,50V 20%,AXL,Z5U .35"Dx.69"L	MA605E475MAA	AVX	1510-16-4475	2.000
C1548*	CAP,CER,5.1pF,200V +/-.5pF,NPO,T/R .10"X.17L"	SA102A5R1DAA-T/R	AVX	1510-16-4519	1.000
C1549*	CAP,CER,200V,47PFT/R	C114C470J2G5CA	KEMET	1510-16-8470	1.000
C1550	CAP,CER,.47uF,50V 20%,AXL,Z5U .15"D x .29"L	SA305E474MAA	AVX	1510-17-1474	1.000
C1551 C1556 C1557 C1560 C1562	CAP,CER,.01uF,50V 10%,AXL,X7R .10"Dx.17"L	SA105C103KAA	AVX	1510-17-1103	5.000
C1552	CAP,CER,56PF,100V 10%,AXL,.09"Dx.16"L T/R	CK12BX560K	AVX	1510-16-2560	1.000
C1553	CAP,CER,560pF,50V 10%,AXL,NPO.1"Dx.17"L	SA101A561JAA	AVX	1510-17-1561	1.000
C1554 C1569	CAP,CER,180pF,100V 5%,AXL,NPO .10"Dx.17"L,T/R	SA101A181JAA	AVX	1510-17-1181	2.000
C1558 C1559	CAP,TNT,10uF,25V, 20%,AXL,D=3% .18"x.345"	173D106X9025W	SPR	1510-21-7100	2.000
C1572	CAP,CER,75pF,50V 5%,AXL,NPO.09"Dx.16"L	C114G750J2G5CA	KEM	1510-16-8750	1.000
CR1501 CR1502 CR1505	DIODE,SIGNAL,GP AXIAL,V=75V,IO=10mA CT=4pF,*SS*	1N914	G-E	4807-01-0914	3.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
CR1503	DIODE,ZENER,500mW,GP DO-35,V=5.1,IT=20mA IF=89mA,+/-20%,*SS*	1N5231	MOT	4801-01-5231	1.000
CR1504	DIODE,VARACTOR,UHF TUN,AXIAL,V=28V CT=17.5pF,*SS*	BB505B	SIEM	4803-02-0020	1.000
IC1501	DCDR/DEMUX,1-OF-8 PLAS,DIP-16 H SPD CMOS,*SS*	MC74HC138N	MOT	8007-41-3811	1.000
IC1502	BUFFER,OCTAL,3 STATE PLAS,DIP-20,*SS* HIGH SPEED CMOS	MC74HC541N	MOT	8007-45-4110	1.000
IC1503 IC1504	OCT 3-STATE NON-INV D-TYPE FLIP-FLOP*SS* PLASTIC,DIP-20 CMOS	MC74HC574N	MOT	8007-45-7410	2.000
IC1505	VOLT REG,+15V,3-TERM PLAS,TO-92,35Vdc 5%,100mA,*SS*	LM78L15ACZ	NAT	7000-78-1520	1.000
IC1506	VOLT REG,+5V,3-TERM PLAS,TO-92,35Vdc 5%,Io=100mA,*SS*	671-045	W-I	7000-78-0501	1.000
IC1507 IC1508 IC1509	UP/DN CNTR,4 BIT,DEC PLAS,DIP-16 H-SPD, CMOS,PRESETABLE,*SS*	MM74HC190	NAT	8007-41-9010	3.000
IC1512	JFET OP AMP,DUAL LW OFFSET,LOW DRIFT PLAS,DIP-8,*SS*	LF412ACN	NAT	7000-04-1211	1.000
IC1513	OP AMP,QUAD,LOW PWR PLAS,DIP-14,30V 1MHz,45nAdc,*SS*	LM324N	NAT	7000-03-2400	1.000
IC1514	ANLG SW,QUAD,SPST CERM,DIP-16,CMOS*SS*	DG201ACJ	SCX	8000-02-0101	1.000
IC1516	PRESCALER,LOW PWR DIV/32,225 MHZ, PL,DIP-4,*SS*	SC63597P	MOT	8001-20-1510	1.000
IC1517	HEX INV,CMOS PLAS,DIP-14,*SS*	MC74HC04N	MOT	8000-74-0411	1.000
IC1518	PHASE DETECTOR,CMOS, BROADBAND,FREQ SYNT, 8PIN PLASTIC DIP*SS*	IMI4345008PB	IMI	8000-43-4500	1.000
IC1519	VOLT COMP,DUAL PLAS,DIP-8,2-36Vdc 25nAdc,*SS*	LM393N	NAT	7000-03-9310	1.000
IC1520	VOLT,REG,FIXED,-15V PLAS,TO-226AA,-35Vdc 10%,Io=100mA,*SS*	LM79L15ACZ	NAT	7000-79-1510	1.000
IC1521 IC1522	CNTR,BIN RPL,DUAL PLS,DIP-16 H SPD CMOS,*SS*	MM74HC390N	NAT	8007-43-9011	2.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
J1501 J1502	CONN,SMA-F,50,PC MT RT ANG	42-302-1	CNTRS	2110-02-0017	2.000
L1501	CHOKE,COATED,1UH,10% D=0.120IN,L=0.300IN, I=385MA	08N1RO	JEF	1810-03-0010	1.000
L1502 L1503	CHOKE,COATED,22UH 10%,D=0.120IN, L=0.300IN,I=140MA	09C220K	JEF	1810-03-0220	2.000
L1504 L1505	CHOKE,COATED,100UH 10%,D=0.120IN, L=0.300IN,I=84MA	08N101	JEF	1810-03-0101	2.000
MX1501	MIXER,DBL BAL,*SS*	SBL-1-DBL	MIN-C	3010-54-0004	1.000
P1501	D-CONN,FILTERED,37 PIN,RT ANGLE,MALE, 500 PF	FDX37M5R7NOX	POSIT	2112-04-0024	1.000
Q1501 Q1504 Q1505 Q1509	NPN,TO-92,GP AMP/SW F=300,V-40,Icex=50nA P=625mW,hFE=100,*SS*	2N3904	NAT	4901-03-9040	4.000
Q1502 Q1508	JFET-N,TO-92,GP AMP AUDIO,V=25,Igss=-1nA P=310mW,NF=2.5,SS#1	2N5458	MOT	4901-05-4580	2.000
Q1503	NPN,TO-72,GP AMP F=60,V=12,Iceo=.02uA P+200mW,NF=4.5,*SS*	2N5179	RCA	4901-05-1790	1.000
Q1506 Q1507	PNP,TO-92,GP AMP/SW F=300,V=40,Icex=50nA P=625mW,hFE=100,*SS*	2N3906	MOT	4901-03-9060	2.000
R1505 R1547	(P)RES,MF,2K,1% 1/4W,AXL,TC=100ppmT/R	MF55D2001FL	KOA	4701-03-2001	2.000
R1506 R1542 R1548 R1549 R1564 R1565 R1566 R1567	(P)RES,MF,4.99K,1% 1/4W,AXL,TC=100ppmT/R	MF55D4991FL	KOA	4701-03-4991	8.000
R1507	(S)RES,MF,825,1% 1/4W,AXL,TC=100ppmT/R	MF55D8250FL	KOA	4701-03-8250	1.000
R1509 R1559	(S)RES,MF,681,1% 1/4W,AXL,TC=100ppmT/R	MF55D6810FL	KOA	4701-03-6810	2.000
R1510 R1543	(S)RES,MF,200,1% 1/4W,AXL,TC=100ppmT/R	MF55D2000FL	KOA	4701-03-2000	2.000
R1511 R1544	(S)RES,MF,37.4,1% 1/4W,AXL,TC=100ppmT/R	MF55D3749FL	KOA	4701-03-3749	2.000
R1512 R1513 R1545 R1546	(P)RES,MF,150,1% 1/4W,AXL,TC=100ppmT/R	MF55D1500FL	KOA	4701-03-1500	4.000
R1514	(S)RES,MF,68.1,1% 1/4W,AXL,TC=100ppmT/R	MF55D6819FL	KOA	4701-03-6819	1.000
R1515 R1516	(S)RES,MF,95.3,1% 1/4W,AXL,TC=100ppmT/R	MF55D9539FL	KOA	4701-03-9539	2.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
R1517 R1518	(S)RES,MF,845K,1% 1/4W,AXL,TC=100ppmT/R	MF55D8453FL	KOA	4701-03-8453	2.000
R1519 R1521 R1534 R1568 R1569	(P)RES,MF,4.22K,1% 1/4W,AXL,TC=100ppmT/R	MF55D4221FL	KOA	4701-03-4221	5.000
R1522 R1523 R1540	(P)RES,MF,100,1% 1/4W,AXL,TC=100ppmT/R	MF55D1000FL	KOA	4701-03-1000	3.000
R1524 R1526	(P)RES,MF,20K,1% 1/4W,AXL,TC=100ppmT/R	MF55D2002FL	KOA	4701-03-2002	2.000
R1525 R1528 R1560 R1562 R1563	(P)RES,MF,10K,1% 1/4W,AXL,TC=100ppmT/R	MF55D1002FL	KOA	4701-03-1002	5.000
R1529 R1532	(P)RES,MF,100K,1% 1/4W,AXL,TC=100ppmT/R	MF55D1003FL	KOA	4701-03-1003	2.000
R1530 R1531	(S)RES,MF,60.4K,1% 1/4W,AXL,TC=100ppmT/R	MF55D6042FL	KOA	4701-03-6042	2.000
R1533 R1537 R1538 R1557 R1575	(P)RES,MF,1K,1% 1/4W,AXL,TC=100ppmT/R	MF55D1001FL	KOA	4701-03-1001	5.000
R1536 R1550 R1554 R1571 R1572	(P)RES,MF,49.9K,1% 1/4W,AXL,TC=100 PPM T/R	MF55D4992FL	KOA	4701-03-4992	5.000
R1539	(S)RES,MF,475,1% 1/4W,AXL,TC=100ppmT/R	MF55D4750FL	KOA	4701-03-4750	1.000
R1551 R1561	(P)RES,MF,16.9K,1% 1/4W,AXL,TC=100ppmT/R	MF55D1692FL	KOA	4701-03-1692	2.000
R1552 R1553	(S)RES,MF,22.1,1% 1/4W,AXL,TC=100ppmT/R	MF55D2219FL	KOA	4701-03-2219	2.000
R1555	(P)RES,MF,3.01K,1% 1/4W,AXL,TC=100ppmT/R	MF55D3011FL	KOA	4701-03-3011	1.000
R1556	(P)RES,MF,200K,1% 1/4W,AXL,TC=100ppmT/R	MF55D2003FL	KOA	4701-03-2003	1.000
R1570 R1573	(P)RES,MF,1M,1% 1/4W,AXL,TC=100ppmT/R	MF55D1004FL	KOA	4701-03-1004	2.000
R1574	(S)RES,MF,4.75K,1% 1/4W,AXL,TC=100ppmT/R	MF55D4751FL	KOA	4701-03-4751	1.000
R1576	(S)RES,MF,274,1% 1/4W,AXL,TC=100 PPM T/R	MF55D2740FL	KOA	4701-03-2740	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
1	HYBRID PTS, KIT, DOUBLER,2410R	1219-00-0768	W-I ,	1219-00-0768	1.000
2	SCREW,STNLS,PPH,4-40 X 1/4	23022	F-S	2810-23-0064	1.000
3	LOCK WASHER,NO.4 CRES.INT.STARSTNLS.	99402	F-S	2810-28-0047	1.000
4	HEX NUT 4-40 CRES. STNLS.	70202	F-S	2810-16-0023	1.000
5	THERMALCOTE THERMAL JOINT COMPOUND	THERMALLOY INC	ANY	1610-04-0015	0.001
FL1500	2410 DBL SWITHCHED FILTER BANK	1011-25-0004	W-I	1011-25-0004	1.000
G1500	FREQ DOUBLER	SK-2	MIN-C	3010-51-0002	1.000
IC1506	VOLT REG,FIXED,+15V PLAS,3 PIN(TO-220) 35Vdc,.1%,700mA,*SS*	LM78M15CT	NAT	7000-78-1500	1.000
J1500 J1501	CONN,SMA-F,50,PC MT RT ANG	42-302-1	CNTRS	2110-02-0017	2.000
P1500	D-CONN,FILTERED,37 PIN,RT ANGLE,MALE, 500 PF	FDX37M5R7NOX	POSIT	2112-04-0024	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
2	ENCLOSURE HANDLE, 24XX & 24XXR	1410-30-8900	W-I	1410-30-8900	2.000
3	GUIDE PIN .150 O.D.	1410-30-8910	W-I	1410-30-8910	2.000
4	FRONT END CAP, RF SYNTH & DOUBLER, FROM:3210-02-0025	1410-60-4278	W-I	1410-60-4278	1.000
5	REAR ENCLOSURE END CAP,2407	1410-60-4120	W-I	1410-60-4120	1.000
6	REAR ENCLOSURE GASKET,2407	1410-60-4180	W-I	1410-60-4180	1.000
7	FRONT ENCLOSURE GASKET,2407	1410-60-4190	W-I	1410-60-4190	1.000
8	RF ENCLOSURE WITH CENTER WALL,24XX FROM:3210-06-0051	1410-80-2590	W-I	1410-80-2590	1.000
9	SCREW 4-40X1/4" PPH THREAD CUTTING,TYPE1 ZINC PLATED	2810-22-0008	ANY	2810-22-0008	14.000
10	SCW,82 PFUCUT, 4-40X3/16	PER DESC2810-23-0091	F-S	2810-23-0091	6.000
11	SEMS-PPH-INT 4-40 X 3/8 NPPER B/P	PER DESC2810-57-4106	F-S	2810-57-4106	4.000
12	NUT 3/8 ACROSS FLATS .250-36 THREAD	2810-16-0030	F-S	2810-16-0030	4.000
13	I,LW,1/4X.408X.018 HW102-000	30-120	F-S	2810-28-0001	4.000
14	(C)WASHER,.255X7/16	97017	F-S	2810-26-0004	4.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
1	PCB,DOUBLER,2410	1710-30-0129	W-I	1710-30-0129	1.000
C1500 C1502 C1503 C1504 C1505 C1506 C1507 C1508 C1509 C1510 C1512 C1513 C1514 C1518 C1519 C1520 C1521 C1550 C1551 C1552 C1553	(P)CAP,CER,.001uF 100V,20%,CHP,X7R 0805,T/R,VALUE MARKD	08051C102MAT050M	AVX	1510-06-7102	21.000
C1501 C1511 C1515 C1516 C1517 C1522 C1523 C1524 C1525 C1546 C1547 C1548 C1549 C1554	(P)CAP,CER,.01uF,50V 20%,CHP,X7R,0805,T/R VALUE MARKED	08055C103MAT050M	AVX	1510-06-7103	14.000
C1526 C1527 C1528 C1529 C1530 C1531 C1532 C1533 C1534 C1535 C1536 C1537 C1538 C1539	(P)CAP,CER,100PF,50V 1%,CHIP,NPO,+1-30PPM 0805,T/R,VALUE MARKD	C2012C0G1H101FT	TDK	1510-06-5101	14.000
C1540 C1541 C1542 C1543 C1544 C1545	CAP,TANT,10 UF,25V SURFACE MOUNT,T/R	NRD106M25R12	NEC	1510-27-9106	6.000
CR1500 CR1501 CR1502 CR1503 CR1504	DIODE,PIN,GP,ODS-07 V=100V,CJ=0.4pF *SS*,T/R	HSMP3800L31	H-P	4805-02-0016	5.000
CR1505 CR1506	DIODE,HOT CAR,SOT-23 SMD,V=4VCT=1pF,*SS*	MMBD101	MOT	4809-02-0015	2.000
IC1500	MMIC BROADBAND AMP SMD PACK,*SS*,T/R 50OHM,8DB GN @1GHZ	MSA-0486-TR1	AVT	7000-04-8600	1.000
IC1501 IC1502 IC1512	MMIC BROADBAND AMP SMD PACK,*SS*,T/R 50OHM,12DB GN@1GHZ	MSA-0386-TR1	AVT	7000-03-8601	3.000
IC1503	DCDR/DEMUX,1-OF-8, PLAS,SO-16,H-SPD, CMOS,*SS*	MC74HC138D	MOT	8007-41-3812	1.000
IC1504	BUF,OCT,3 STATE, PLAS,SO-20,*SS*,HCMOS	MC74HC541DW	MOT	8007-45-4111	1.000
IC1505	OCT,3-ST D-FLIP FLOP PLAS,SO-20,*SS*,HCMOS	MC74HC574DW	MOT	8007-45-7411	1.000
IC1507	-15V VOLTAGE,REG,PLS PLAS,20-8,*SS*, Io=100mA	MC79L15ACD	MOT	7000-79-1511	1.000
IC1508	VOLTAGE REG PLAS, SO-8,5V,100MA,5%	MC78L05ACD	MOT	7000-78-0511	1.000
IC1509	OP MP,QUAD,VCC=30V SO-14,*SS*	LM324AM	NAT	7000-03-2401	1.000
IC1510	ANLG SW.,QUAD, SPST, PLAS,SO-16,CMOS	DG201ADY	SCX	8000-02-0102	1.000
IC1511	DUAL JFET INPUT OP AMP,SO-8*SS*	MC34002AD	MOT	7003-40-0210	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
L1500 L1501 L1502 L1503 L1504	CHOKE,CHIP,0.22UH 20%,MOLDED,.18"L X .12"W,T/R	LEM4532TR22M	TAIYO	1816-02-0221	5.000
L1505 L1506 L1507 L1508 L1509 L1510 L1511 L1512 L1513 L1514 L1515 L1516 L1517 L1518	BEAD,SHIELD,SURF MNT TAPE & REEL	2743019447	FRTE	1813-00-0111	14.000
Q1500 Q1501 Q1502 Q1503	NPN,SOT-23,MED PWR F=250m,V=40,P=310m, hFE=40,*SS*,T/R	BSS79CE6237	SIEM	4902-00-0170	4.000
Q1504 Q1505 Q1506 Q1507	PNP,SOT-23,MED PWR F=200m,V=40,P=350m, hFE=40,*SS*,T/R	BSR18A-TRL	APX	4902-00-0800	4.000
R1500 R1501 R1502 R1503 R1504 R1505 R1515 R1516 R1517 R1518 R1519 R1520 R1521 R1533 R1536 R1538 R1539 R1540 R1541 R1548	(S)RES,CHP,301,1% 1/8W,TC=100ppm,T/R 1206	RMC 1830191C	KMYO	4711-03-3010	20.000
R1506 R1507 R1508 R1512 R1513 R1514 R1524 R1525 R1544 R1545 R1546 R1547	RES,CHP,604,1% 1/8W,TC=100ppm,T/R 1206	RMC1860491C	KMYO	4711-03-6040	12.000
R1509	RES,CHP,249,1% 1/8W,TC=100ppm,T/R 1206	RMC 1824991C	KMYO	4711-03-2490	1.000
R1510 R1511	(S)RES,CHP,61.9,1% 1/8W,TC=100ppm,T/R 1206	RMC 1861981C	KMYO	4711-03-6199	2.000
R1522 R1523 R1535	(P)RES,CHP,100,1% 1/8W,TC=100ppm,T/R 1206	RMC1810091C	KMYO	4711-03-1000	3.000
R1526 R1527 R1530 R1531 R1532 R1534	(P)RES,CHP,100K,1% 1/8W,TC=100ppm,T/R 1206	RMC1810031C	KMYO	4711-03-1003	6.000
R1528	(S)RES,CHP,332K,1% 1/8W,1206,TC=100 PPM T/R	RK73H2B3323F	KOA	4711-03-3323	1.000
R1529	(S)RES,CH,3.57K,1%, 1/8W,TC=100PPM,T/R 1206	RK73H2B3571F	KOA	4711-03-3571	1.000
R1537	(S)RES,CHP,51.1,1% 1/8W,TC=100ppm,T/R 1206 CASE	RMC1851181C	KMYO	4711-03-5119	1.000
R1542 R1543	(P)RES,CHP,10.0K,1% 1/8W,TC=100ppm,T/R 1206	RMC1810021C	KMYO	4711-03-1002	2.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
C1 C10 C11 C2 C3 C4 C5 C6 C7 C8 C9	CAP,CER,1000PF,50V 5%,CHP,NPO,30PPM .05"X.05" CASE	ATC700A102JP50X	ATC	1510-00-6102	11.000
C1A C1B C2A C2B C2C C2D	(C)CAP,POR,1.4pF,50V +/-.1CHP,P90,20PPM .055"x.055"	ATC100A1R4BP50X	ATC	1510-00-6149	6.000
C1C C1D	(C)CAP,POR,2.2pF,50V +/-.25,CHP,P90,20PPM .055"x.055"	ATC100A2R2CP50X	ATC	1510-00-6229	2.000
C1E C1F	(C)CAP,POR,3pF,50V +/-.25,CHP,P90,20PPM .055"x.055"	ATC100A3R0CP50X	ATC	1510-00-6309	2.000
C2E C2F C2G C2H	(C)CAP,POR,2pF,50V +/-.1,CHP,P90,20PPM .055"x.055"	ATC100A2R0BP50X	ATC	1510-00-6209	4.000
C2I C2J C2K C2L	(C)CAP,POR,2.7pF,50V +/-.25,CHP,P90,20PPM .055"x.055"	ATC100A2R7CP50X	ATC	1510-00-6279	4.000
CR1 CR10 CR11 CR12 CR13 CR14 CR15 CR16 CR17 CR18 CR2 CR3 CR4 CR5 CR6 CR7 CR8 CR9	DIODE,PIN,GP,ODS-07 V=100V,CJ=0.4pF *SS*,T/R	HSMP3800L31	H-P	4805-02-0016	18.000
K1A K1B	(C)CAP,POR,1pF,50V +/-.1,CHP,P90,20PPM .055"x.055"	ATC100A1R0BP50X	ATC	1510-00-6109	2.000
K1C K1D	(C)CAP,POR.1.1pF,50V +/-.1,CHP,P90,20PPM .055"x.055"	ATC100A1RBP50X	ATC	1510-00-6119	2.000
K1E K1F	CAP,POR,1.8pF,50V +/-.1,CHP,P90,20PPM .055"x.055"	ATC100A1R8BP50X	ATC	1510-00-6189	2.000
R1 R10 R2 R3 R4 R5 R6 R7 R8 R9	(S)RES,CHP,1.30K,1% 1/8W,TC=100ppm,T/R 1206	RMC 1813011C	KMYO	4711-03-1301	10.000
S1A S1B	(C)CAP,POR,5.1pF,50V +/-.25,CHP,P90,20PPM .055"x.055"	ATC100A5R1CP50X	ATC	1510-00-6519	2.000
S1C S1D	(C)CAP,POR,6.8pF,50V 5%,CHP,P90,20PPM .055"x.055"CASE	ATC100A6R8JP50X	ATC	1510-00-6689	2.000
S1E S1F	(C)CAP,POR,9.1pF,50V 5%,CHP,P90,20PPM .055"x.055"CASE	ATC100A9R1JP50X	ATC	1510-00-6919	2.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
1	PC BD,RF SYNTH,2410A	1710-30-0144	W-I	1710-30-0144	1.000
2	SCREW,STNLS,PPH,4-40 X 1/4	23022	F-S	2810-23-0064	3.000
3	LOCK WASHER,NO.4 CRES.INT.STARSTNLS.	99402	F-S	2810-28-0047	3.000
4	HEX NUT 4-40 CRES. STNLS.	70202	F-S	2810-16-0023	3.000
5	SHLDR WSHR,NYLON INSULATING BUSHING, TO-220	B51547F019	MOT	2810-11-0031	1.000
6	MICA INSULATOR	B08853A001	MOT	2810-11-0004	1.000
7	NUT,KEPS,4	71500	F-S	2810-16-0026	4.000
8	SCW,PPH,4-40X1/4	19022NP	F-S	2810-55-4104	4.000
C400 C407 C408 C409 C410 C411 C412 C415 C417 C419 C421 C425 C426 C429 C430 C441 C444 C445 C446 C448 C449 C452 C453 C462 C477 C478	CAP,CER,.1uF,50V 20%,AXL,Z5U .10"Dx.26"L	SA205E1042AA	AVX	1510-17-1104	26.000
C401 C402 C403 C404 C405 C406 C432 C447 C450 C455 C457 C459 C461	CAP,TNT,1uF,25V 10%,AXL.095"Dx.260"L	173D105X9025U	SPR	1510-21-7010	13.000
C414 C416 C427 C431 C440 C443 C490 C494 C495 C496 C497 C498 C499 C590 C591 C592 C595 C596 C597	CAP,CER,1000pF,50V 10%,AXL,X7R .09"Dx.16"L	RPA10X7R102K50VPT	MURGA	1510-16-8102	19.000
C418 C434 C451 C454 C483 C484	CAP,CER,.01uF,50V 10%,AXL,X7R .10"Dx.17"L	SA105C103KAA	AVX	1510-17-1103	6.000
C428 C433	CAP,CER,1uF,50V 10%,AXL,X7R .25"Dx.50"L	C202C105K5R5CA	KEM	1510-16-6105	2.000
C435 C476	4700 PF 20% 100V X7R AXIAL LEAD,TAPE/REEL	C410C472M1R5CA	KEM	1510-17-1472	2.000
C456 C460	CAP,TNT,3.3UF,25V, 10%,AXL,.110X.290	T322B335K025AS	KEM	1510-21-7339	2.000
C491 C492	CAP,TNT,10uF,25V, 20%,AXL,D=3% .18"x.345"	173D106X9025W	SPR	1510-21-7100	2.000
C493	CAP,TNT,68uF,25V,10% RAD,DIPPED .35"x.73",.20"LS	T353L686K025AS	KEMET	1510-22-7680	1.000
C593 C594	CAP,CER,15pF,50V 5%,AXL,NPO.09"Dx.16"L	NAD 15J 50V NPO	NIC	1510-16-8150	2.000
CR401 CR402 CR404	DIODE,SIGNAL,GP AXIAL,V=75V,IO=10mA CT=4pF,*SS*	1N914	G-E	4807-01-0914	3.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
CR403	DIODE,ZENER,500mW,GP DO-35,V=5.1,IT=20mA IF=89mA,+/-20%,*SS*	1N5231	MOT	4801-01-5231	1.000
IC400	DCDR/DEMUX,1-OF-8 PLAS,DIP-16 H SPD CMOS,*SS*	MC74HC138N	MOT	8007-41-3811	1.000
IC401	POS. VOLT REG-3 TERM PLAS,TO-220AB,5 VOLT 500mA,7 W,5%,3-TERM	UA78M05CKC	T-I	7000-78-0500	1.000
IC402	VOLT REG,FIXED,+15V PLAS,3 PIN(TO-220) 35Vdc,.1%,700mA,*SS*	LM78M15CT	NAT	7000-78-1500	1.000
IC403	VOLT REG,-15V,3-TERM PLAS,TO-220,35Vdc 5%,1.5W,1.0A	UA79M15CKC	T-I	7000-79-1500	1.000
IC404 IC405	OCT 3-STATE NON-INV D-TYPE FLIP-FLOP*SS* PLASTIC,DIP-20 CMOS	MC74HC574N	MOT	8007-45-7410	2.000
IC406	BUFFER,OCTAL,3 STATE PLAS,DIP-20,*SS* HIGH SPEED CMOS	MC74HC541N	MOT	8007-45-4110	1.000
IC407 IC408	PLL FRQ SYN,D BUS IN PLAS,DIP-20,CMOS*SS*	MC145146P1	MOT	8014-51-4610	2.000
IC409	ADDER,4-B BINARY PLAS,DIP-16 H SPD CMOS,*SS*	MC74HC283N	MOT	8007-42-8311	1.000
IC410	PRESC,2-MOD,DIV 5/6 PLAS,DIP-16,ECL,*SS*	MC12009P	MOT	8001-20-0910	1.000
IC411 IC417	OP AMP,JFET INPUT PLAS,DIP-8,18Vdc 13V/uS,*SS*	TL082CP	T-I	7000-00-8200	2.000
IC413	ANLG SW,CMOS CERM,DIP-14,*SS*	DG303ACJ	SCX	8000-03-0310	1.000
IC414	MULTIPLYING DAC,BFRD DUAL,8-BIT,CMOS PLAS,DIP-20,*SS*	AD7528JN	A-D	8000-75-2810	1.000
IC416	PRESC,2-MOD,DIV B 10 PLAS,DIP-16,ECL*SS*	MC12013PC	MOT	8001-20-1300	1.000
IC418	OP AMP,QUAD,LOW PWR PLAS,DIP-14,30V 1MHz,45nAdc,*SS*	LM324N	NAT	7000-03-2400	1.000
IC419	ANLG SW,QUAD,SPST CERM,DIP-16,CMOS*SS*	DG201ACJ	SCX	8000-02-0101	1.000
IC420 IC421 IC422	WIDEBAND HI FREQ AMP PLAS,DIP-8,*SS*	NE5205N	SIG	7000-52-0510	3.000
IC423	NAND GATE,QUAD 2-INP PLAS,DIP-14,*SS* H-SPD CMOS-LSTTL	MC74HC00N	MOT	8000-74-0012	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
IC500	PCB ASSY,VCO,24XXA	1218-00-2628	W-I	1218-00-2628	1.000
IC501	PHASE DETECTOR,CMOS, BROADBAND,FREQ SYNT, 8PIN PLASTIC DIP*SS*	IMI4345008PB	IMI	8000-43-4500	1.000
J501 J502	CONN,SMA-F,50,PC MT RT ANG	42-302-1	CNTRS	2110-02-0017	2.000
L404 L406	CHOKE,MOLDED,1MH	15S102K	JEF	1810-02-0102	2.000
L405	CHOKE,COATED,10UH 10%,D=0.120IN, L=0.300IN,I=130MA	09C100K	JEF	1810-03-0100	1.000
L407	COIL,MOLDED,33nH,5% RAD,L=0.38",W=0.23", H=0.26"Q=64@,F=50MHz	132-02	CLCFT	1810-14-0330	1.000
P401	D-CONN,FILTERED,37 PIN,RT ANGLE,MALE, 500 PF	FDX37M5R7NOX	POSIT	2112-04-0024	1.000
Q402	NPN,TO-18 GP SWITCH, AMP,FT=300,V=30,P=0. 5W,HFE=300MAX,IC=800	2N2222	MOT	4901-02-2221	1.000
Q403	NPN,GP AMP,SW,TO-39, TURN ON=40NS,HFE MIN =2.5,V=30V,IC=1.5A	2N3734	MOT	4901-03-7340	1.000
Q404	PNP,TO-39,SWITCH,V=4 0V,PD=1W,IC=1A,HFE40 -120,FT=150,VCE,=0.3	2N3467	MOT	4901-03-4670	1.000
Q405	PNP,TO-18,GP SW,AMP, FT=200,V=40,P=0.4W, HFE=300 MAX,IC=600	2N2907	MOT	4901-02-9070	1.000
R400 R401 R412 R413 R415 R416 R418 R420 R431 R432 R436 R444 R445 R446 R447	(P)RES,MF,10K,1% 1/4W,AXL,TC=100ppmT/R	MF55D1002FL	KOA	4701-03-1002	15.000
R402 R424 R427 R428	(S)RES,MF,475,1% 1/4W,AXL,TC=100ppmT/R	MF55D4750FL	KOA	4701-03-4750	4.000
R403 R429 R476	(P)RES,MF,1K,1% 1/4W,AXL,TC=100ppmT/R	MF55D1001FL	KOA	4701-03-1001	3.000
R406 R407	(S)RES,MF,665K,1% 1/4W,AXL,TC=100ppmT/R	MF55D6653FL	KOA	4701-03-6653	2.000
R408 R409 R410 R411 R417 R419 R421 R422	(P)RES,MF,20K,1% 1/4W,AXL,TC=100ppmT/R	MF55D2002FL	KOA	4701-03-2002	8.000
R414	(P)RES,MF,100K,1% 1/4W,AXL,TC=100ppmT/R	MF55D1003FL	KOA	4701-03-1003	1.000
R430	(S)RES,MF,51.1,1% 1/4W,AXL,TC=100ppmT/R	MF55D5119FL	KOA	4701-03-5119	1.000
R433	(S)RES,MF,10,1% 1/4W,AXL,TC=100ppmT/R	MF55D1009FL	KOA	4701-03-1009	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
R451	(S)RES,MF,392,1% 1/4W,AXL,TC=100ppmT/R	MF55D3920FL	KOA	4701-03-3920	1.000
R452 R453	(P)RES,MF,100,1% 1/4W,AXL,TC=100ppmT/R	MF55D1000FL	KOA	4701-03-1000	2.000
R454 R456 R465 R466	(S)RES,MF,68.1,1% 1/4W,AXL,TC=100ppmT/R	MF55D6819FL	KOA	4701-03-6819	4.000
R455 R457 R458 R459 R460 R461 R462 R463 R464	(S)RES,MF,182,1% 1/4W,AXL,TC=100ppmT/R	MF55D1820FL	KOA	4701-03-1820	9.000
R477	(P)RES,MF,1.50K,1% 1/4W,AXL,TC=100ppmT/R	MF55D1501FL	KOA	4701-03-1501	1.000
R478	(P)RES,MF,15K,1% 1/4W,AXL,TC=100ppmT/R	MF55D1502FL	KOA	4701-03-1502	1.000
R486 R487 R489 R490	(S)RES,MF,5.11K,1% 1/4W,AXL,TC=100ppmT/R	MF55D5111FL	KOA	4701-03-5111	4.000
R488 R491	(P)RES,MF,499,1% 1/4W,AXL,TC=100ppmT/R	MF55D4990FL	KOA	4701-03-4990	2.000
R492 R493 R494	(P)RES,MF,4.99K,1% 1/4W,AXL,TC=100ppmT/R	MF55D4991FL	KOA	4701-03-4991	3.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
1	VCO COVER,2407	1410-30-9090	W-I	1410-30-9090	1.000
LX502	COIL-AIR,4-1/2T,.125 ID.(20GA)	1815-00-0205	W-I	1815-00-0205	1.000
LX508	COIL-AIR,3T,.125 ID. 20 GA	1815-00-0206	W-I	1815-00-0206	1.000
Q502	NPN,TO-35,AMP F=9G,V=10,JCBO=1.0uA P=290mW,HFE=100,*SS*	NE68135	NEC	4902-68-1350	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
P7A	CONN,HSG,20-PIN	102398-8	AMP	2113-36-0008	1.000
P7B	CONN,POL CVR,20-PIN	102540-8	AMP	2113-33-0029	1.000
P7C	CONN,BACK CVR,20-PIN	102536-8	AMP	2113-33-0018	1.000
P9	HSG,MINI-LATCH,10PIN MC000-130	65039-027	BER	2113-10-0010	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
2	ENCLOSURE HANDLE, 24XX & 24XXR	1410-30-8900	W-I	1410-30-8900	2.000
3	GUIDE PIN .150 O.D.	1410-30-8910	W-I	1410-30-8910	2.000
4	FRONT ENCLOSURE END CAP,AM/DIV&OUTPUT2407	1410-60-4090	W-I	1410-60-4090	1.000
5	REAR ENCL END CAP AM/DIV & OUTPUT2407	1410-60-4170	W-I	1410-60-4170	1.000
6	REAR ENCLOSURE GASKET,2407	1410-60-4180	W-I	1410-60-4180	1.000
7	FRONT ENCLOSURE GASKET,2407	1410-60-4190	W-I	1410-60-4190	1.000
8	RF ENCLOSURE WITH CENTER WALL,24XX FROM:3210-06-0051	1410-80-2590	W-I	1410-80-2590	1.000
9	SCREW 4-40X1/4" PPH THREAD CUTTING,TYPE1 ZINC PLATED	2810-22-0008	ANY	2810-22-0008	14.000
10	SCW,82 PFUCUT, 4-40X3/16	PER DESC2810-23-0091	F-S	2810-23-0091	6.000
11	SEMS-PPH-INT 4-40 X 3/8 NPPER B/P	PER DESC2810-57-4106	F-S	2810-57-4106	4.000
12	NUT 3/8 ACROSS FLATS .250-36 THREAD	2810-16-0030	F-S	2810-16-0030	6.000
13	I,LW,1/4X.408X.018 HW102-000	30-120	F-S	2810-28-0001	6.000
14	(C)WASHER,.255X7/16	97017	F-S	2810-26-0004	6.000
A700	PC ASSY,AM/DIV,2410A	1110-00-2340	W-I	1110-00-2340	1.000
A800	PC ASSY,OUTPUT,2410A	1110-00-2341	W-I	1110-00-2341	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
2	SCW,PPH,4-40X1/4	19022NP	F-S	2810-55-4104	1.000
3	LO,WASHER,INT,4 HW101-400	1331NP	F-S	2810-24-4000	1.000
4	NUT,4-40,HN101-400	8002A-NP	F-S	2810-14-4100	1.000
IC700	PRESCALER,H-SPD PLAS,DIP-16,*SS* MECL,TYPE D FF	MC12090P	MOT	8001-20-9010	1.000
IC702 IC703 IC715	UWAVE WB AMP,0304*SS*	MSA-0304	AVT	4902-00-3040	3.000
IC704	UWAVE WB AMP,0404*SS*	MSA-0404	AVT	4902-00-4040	1.000
IC707	ANLG SW,QUAD,SPST CERM,DIP-16,CMOS*SS*	DG201ACJ	SCX	8000-02-0101	1.000
IC709	DCDR/DEMUX,1-OF-8 PLAS,DIP-16 H SPD CMOS,*SS*	MC74HC138N	MOT	8007-41-3811	1.000
IC710	BUFFER,OCTAL,3 STATE PLAS,DIP-20,*SS* HIGH SPEED CMOS	MC74HC541N	MOT	8007-45-4110	1.000
IC711	FLOUR DISPLAY DRVR *SS*	UDN-6118A	SPR	8000-61-1800	1.000
IC712	OCT 3-STATE NON-INV D-TYPE FLIP-FLOP*SS* PLASTIC;DIP-20 CMOS	MC74HC574N	MOT	8007-45-7410	1.000
IC713	VOLT REG,FIXED,+15V PLAS,3 PIN(TO-220) 35Vdc,.1%,700mA,*SS*	LM78M15CT	NAT	7000-78-1500	1.000
J700 J701	CONN,SMA-F,50,PC MT RT ANG	42-302-1	CNTRS	2110-02-0017	2.000
P700	D-CONN,FILTERED,37 PIN,RT ANGLE,MALE, 500 PF	FDX37M5R7NOX	POSIT	2112-04-0024	1.000
R750 R776	TRM,CM,L,20K,10%,PC 1T,PN,CW,.19H,.375W .375L,TA	3386R-1-203	BOU	4610-00-3203	2.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
1	PCB,AM/DIVIDER,2407	1710-30-0097	W-I	1710-30-0097	1.000
C700 C701 C702 C711 C712 C713 C719 C720 C721 C722 C723 C724 C727 C728 C734 C735 C755 C756	(P)CAP,CER,.001uF 100V,20%,CHP,X7R 0805,T/R,VALUE MARKD	08051C102MAT050M	AVX	1510-06-7102	18.000
C703 C776 C777 C778 C779 C780 C781 C782 C783 C784 C785 C786 C787 C788 C789 C790 C791 C792 C793 C794 C795 C796 C797 C798 C799 C800 C801 C803 C804 C805 C806 C807 C808 C809 C812 C813 C815 C816 C817	(P)CAP,CER,100PF,50V 1%,CHIP,NPO,+1-30PPM 0805,T/R,VALUE MARKD	C2012C0G1H101FT	TDK	1510-06-5101	39.000
C707 C708 C709	(P)CAP,CER,6.8PF,50V +/-.5PF,CHIP,NPO 0805,T/R,VALUE MARKD	C2012C0G1H6R8DT	TDK	1510-06-5689	3.000
C714 C718	(P)CAP,CER,8.2PF,50V +/-.5PF,CHIP,NPO 0805,T/R,VALUE MARKD	C2012C0G1H8R2DT	TDK	1510-06-5829	2.000
C715 C716 C717 C729 C733	(P)CAP,CER,15PF,50V 1%,CHIP,NPO,+/-30PPM 0805,T/R,VALUE MARKD	C2012C0G1H150FT	TDK	1510-06-5150	5.000
C725 C726 C741 C743 C757	CAP,TANT,1 UF,35V SURFACE MOUNT	NRB105M35R12	NEC	1510-27-9105	5.000
C730 C731 C732	CAP,POR,22pF,50V 5%,CHP,P90,20PPM .07"X.055",T/R	MA18220J	MURGA	1510-02-8220	3.000
C736 C740	(P)CAP,CER,18PF,50V 1%,CHIP,NPO,+/-30PPM 0805,T/R,VALUE MARKD	C2012C0G1H180FT	TDK	1510-06-5180	2.000
C737 C738 C739	(P)CAP,CER,33PF,50V 1%,CHIP,NPO,+1-30PPM 0805,T/R,VALUE MARKD	C2012C0G1H330FT	TDK	1510-06-5330	3.000
C742 C744 C758	CAP,TANT,10 UF,25V SURFACE MOUNT,T/R	NRD106M25R12	NEC	1510-27-9106	3.000
C748 C749 C759 C764 C765 C767 C768 C769 C770 C771 C772 C775 C810 C814 C818	(P)CAP,CER,.01uF,50V 20%,CHP,X7R,0805,T/R VALUE MARKED	08055C103MAT050M	AVX	1510-06-7103	15.000
C762 C763	(P)CAP,CER,220pF,50V 5%,CHIP,NPO,+1-30PPM 0805,T/R,VALUE MARKD	500R15N221JV3E	JHSN	1510-06-5221	2.000
C766 C773	(P)CAP,CER,330PF,50V 5%,CHIP,NPO,+/-30PPM 0805,T/R,VALUE MARKD	500R15N331JV3E	JHSN	1510-06-5331	2.000
C811 C819	CAP,POR,1.2pF,50V +/-.1,CHP,P90,20PPM .07"x.055"	MA181R2B	MURGA	1510-02-8129	2.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
CR700 CR701 CR702 CR703 CR704 CR705 CR706 CR707 CR708 CR711 CR712 CR713 CR714 CR715 CR727 CR728	DIODE,PIN,GP,ODS-07 V=100V,CJ=0.4pF *SS*,T/R	HSMP3800L31	H-P	4805-02-0016	16.000
CR709 CR710	DIODE,PLANAR,HI SPD SWIT,SOT-23,V=75,IO= 250m,SUR,*SS*,T/R	BAS16 TRL	APX	4812-02-0005	2.000
CR722 CR723 CR724 CR725 CR726	DIODE,HOT CAR,SOT-23 SMD,V=4VCT=1pF,*SS*	MMBD101	MOT	4809-02-0015	5.000
CR729 CR730 CR731 CR732	DIODE,PIN,POWER SOT-287,V=100V C=.15pF,*SS*,T/R	MA4P671-T/R	M-A	4805-02-0009	4.000
IC701 IC708	VOLTAGE REG PLAS, SO-8,5V,100MA,5%	MC78L05ACD	MOT	7000-78-0511	2.000
IC705 IC706	DUAL JFET INPUT OP AMP,SO-8*SS*	MC34002AD	MOT	7003-40-0210	2.000
IC714	-15V VOLTAGE,REG,PLS PLAS,20-8,*SS*, Io=100mA	MC79L15ACD	MOT	7000-79-1511	1.000
L700 L703 L747* L749	CHOKE,CHIP,15nH,5%, .12"LX.10"W,MOLDED, T/R	SM3-015J	GWNDA	1816-01-0150	4.000
L701 L702 L705 L706 L707 L708 L745 L746	CHOKE,CHIP,22nH,5%, .12"LX.10"W,MOLDED, T/R	SM3-022J	GWNDA	1816-01-0220	8.000
L709 L720 L721 L723 L744 L748	CHOKE,CHIP,1 UH,20% MOLDED,.18"L X .12"W T/R	LEM4532T1ROM	TAIYO	1816-02-0102	6.000
L710 L711 L712 L713	CHOKE,CHIP,33nH,5%, .12"LX.10"W,MOLDED, T/R	SM3-033J	GWNDA	1816-01-0330	4.000
L714 L715 L716 L717	CHOKE,CHIP,47nH,5%, .12"LX.10"W,MOLDED, T/R	SM3-047J	GWNDA	1816-01-0470	4.000
L724 L726 L727 L728 L729 L730 L731 L732 L733 L734 L735 L736 L737 L738 L739 L740 L741 L743	BEAD,SHIELD,SURF MNT TAPE & REEL	2743019447	FRTE	1813-00-0111	18.000
Q700 Q701 Q702 Q703	NPN,SOT-23,MED PWR F=250m,V=40,P=310m, hFE=40,*SS*,T/R	BSS79CE6237	SIEM	4902-00-0170	4.000
R700	RES,CH,1/8W,5%,0	RMC1/8-0	KMYO	4711-05-0000	1.000
R701	(S)RES,CHP,178,1% 1/8W,TC=100ppm,T/R 1206	RMC1817891C	KMYO	4711-03-1780	1.000
R702 R718* R733 R734 R786 R787 R788 R790 R796 R797 R798 R804 R805 R806	(S)RES,CHP,82.5,1%, 1/8w,TC=100ppm, T/R, 1206	RMC1882581C	KMYO	4711-03-8259	14.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
R703 R712 R715 R717 R726 R728 R792	(S)RES,CHP,475,1% 1/8W,1206,TC=100 PPM T/R	RK73H2B4750F	KOA	4711-03-4750	7.000
R704 R713 R714 R716 R723 R724 R727 R729 R780 R781 R782 R784 R799 R801 R802 R803	RES,CHP,294,1% 1/8W,TC=100ppm,T/R 1206	9C12063A2940FKR	M-E	4711-03-2940	16.000
R719	RES,CHP,1.18K,1% 1/8W,TC=100ppm,T/R 1206	BCK1181FB	A-B	4711-03-1181	1.000
R720	(S)RES,CHP,3.92K,1% 1/8W,1206,TC=100 PPM T/R	RK73H2B3921F	KOA	4711-03-3921	1.000
R721 R722	RES,CHP,118,1% 1/8W,TC=100ppm,T/R 1206	RMC118-118	KMYO	4711-03-1180	2.000
R725 R737 R791	(S)RES,CHP,51.1,1% 1/8W,TC=100ppm,T/R 1206 CASE	RMC1851181C	KMYO	4711-03-5119	3.000
R735 R736 R807 R808 R809	RES,CHP,37.4,1% 1/8W,TC=100ppm,T/R 1206	RMC1837481C	KMYO	4711-03-3749	5.000
R742 R743 R744 R764 R794 R810	(P)RES,CHP,100,1% 1/8W,TC=100ppm,T/R 1206	RMC1810091C	KMYO	4711-03-1000	6.000
R748 R749 R751 R755 R759 R762 R767 R771 R772 R778	(P)RES,CHP,100K,1% 1/8W,TC=100ppm,T/R 1206	RMC1810031C	KMYO	4711-03-1003	10.000
R752 R753 R774 R775	RES,CHP,499K,1% 1/8W,TC=100ppm,T/R 1206	RK73H2B4993F	KOA	4711-03-4993	4.000
R754 R758	(S)RES,CHP,8.25K,1% 1/8W,1206,TC=100 PPM T/R	RK73H2B8251F	KOA	4711-03-8251	2.000
R756 R757	(S)RES,CHP,200K,1% 1/8W,TC=100ppm,T/R 1206	RMC1820031C	KMYO	4711-03-2003	2.000
R760*	(S)RES,CHP,56.2K,1% 1/8W,TC=100ppm,T/R 1206	RK73H2B5622F	KOA	4711-03-5622	1.000
R761 R768	RES,CHP,49.9K,1% 1/8W,TC=100ppm,T/R 1206	RMC1814992	KMYO	4711-03-4992	2.000
R763 R785	(P)RES,CHP,1.0K,1% 1/8W,TC=100ppm,T/R 1206	RMC1810011C	KMYO	4711-03-1001	2.000
R765 R770	RES,CHP,14.7K,1% 1/8W,TC=100ppm,T/R 1206	RMC1814721C	KMYO	4711-03-1472	2.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
R766	(S)RES,CHP,68.1K,1% 1/8W,1206,TC=100 PPM T/R	RK73H2B6812F	KOA	4711-03-6812	1.000
R769	(S)RES,CHP,35.7K,1% 1/8W,1206,TC=100 PPM T/R	RK73H2B3572F	KOA	4711-03-3572	1.000
R773*	(P)RES,CHP,178K,1% 1/8W,TC=100ppm,T/R 1206	RMC1817831C	KMYO	4711-03-1783	1.000
R777	(S)RES,CHP,82.5K,1% 1/8W,1206,TC=100 PPM T/R	RK73H2B8252F	KOA	4711-03-8252	1.000
R779	(S)RES,CH,267K,1%, 1/8W,TC=100PPM,T/R, 1206 CASE	RMC1826731C	KMYO	4711-03-2673	1.000
R783 R800	(P)RES,CHP,10.0K,1% 1/8W,TC=100ppm,T/R 1206	RMC1810021C	KMYO	4711-03-1002	2.000
R793 R795	(P)RES,CHP,150,1% 1/8W,TC=100ppm,T/R 1206	RMC1815091C	KMYO	4711-03-1500	2.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
IC800 IC801 IC803 IC804 IC805 IC809	UWAVE WB AMP,0304*SS*	MSA-0304	AVT	4902-00-3040	6.000
IC810	UWAVE WB AMP,0404*SS*	MSA-0404	AVT	4902-00-4040	1.000
IC811	MMIC BROADBAND AMP, PLAS PKG,50 OHM,8 DB GN @ 1GHZ,*SS*	MSA-0485	AVT	7000-04-8500	1.000
IC812	AMP,WB,2.8GHZ,23dBCP DISK PAC,Vd=12V,G=8.5dB@1GHz,200mA,*SS*	MSA-0520	AVT	7000-05-2000	1.000
IC903	FLOUR DISPLAY DRVR *SS*	UDN-6118A	SPR	8000-61-1800	1.000
IC905	VOLT REG,FIXED,+15V PLAS,3 PIN(TO-220) 35Vdc,.1%,700mA,*SS*	LM78M15CT	NAT	7000-78-1500	1.000
J800 J801 J802 J803	CONN,SMA-F,50,PC MT RT ANG	42-302-1	CNTRS	2110-02-0017	4.000
J804	D-CONN,FILTERED,37 PIN,RT ANGLE,MALE, 500 PF	FDX37M5R7NOX	POSIT	2112-04-0024	1.000
Q804	2IGMOSFET,TO-72,AMP F=500,V=25,Igss=10nA P=360mW,NF=4.5, *SS*	MFE 201	MOT	4903-00-2010	1.000
R812 R820 R851 R869	RES,C,1/2W,5%,220	CF1/2-220	KOA	4700-25-2200	4.000
R849	(S)RES,MF,301,1% 1/4W,AXL,TC=100ppmT/R	MF55D3010FL	KOA	4701-03-3010	1.000
R867	(S)RES,MF,200,1% 1/4W,AXL,TC=100ppmT/R	MF55D2000FL	KOA	4701-03-2000	1.000
R872 R873 R918 R927 R928 R931 R932	RES,C,1/2W,5%,100	CF1/2-100	KOA	4700-25-1000	7.000
R900 R901	TRM,CM,L,10K,10%,PC 1T,PN,CW,.19H,.375W .375L,TA	3386R-1-103	BOU	4610-00-3103	2.000
R923	RES,C,1/2W,5%,68	CF1/2-68	KOA	4700-25-6809	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
C800 C801 C802 C803 C804 C805 C806 C807 C810 C811 C813 C815 C819 C822 C835 C836 C840 C841 C849 C853 C862 C863 C864 C867 C868 C901 C909 C910 C913	(P)CAP,CER,.01uF,50V 20%,CHP,X7R,0805,T/R VALUE MARKED	08055C103MAT050M	AVX	1510-06-7103	29.000
C808 C827 C846 C851	(P)CAP,CER,10PF,50V +/-.5PF,CHIP,NPO 0805,T/R,VALUE MARKD	C2012C0G1H100DT	TDK	1510-06-5100	4.000
C809 C820 C821 C823 C824 C825 C826 C828 C830 C831 C832 C833 C837 C838 C843 C844 C845 C847 C848 C860 C861 C869 C870 C938 C939 C940 C941	(P)CAP,TNT,.1uF,50V +/-20%,CHP,T/R, 1206 CASE	TAJA104M050R	AVX	1510-27-9104	27.000
C812 C814 C829 C834	(P)CAP,CER,22PF,50V 1%,CHIP,NPO,+/-30PPM 0805,T/R,VALUE MARKD	C2012C0G1H220FT	TDK	1510-06-5220	4.000
C816 C817 C818 C842 C850 C852 C857 C858 C859 C865 C866 C902 C905 C907 C911	(S)CAP,CER,.47uF,50V 20%,CHP,Z5U,1812,T/R VALUE MARKED	18125E474MAT050M	AVX	1510-06-7474	15.000
C839 C908 C943 C945 C947	CAP,TANT,10 UF,25V SURFACE MOUNT,T/R	NRD106M25R12	NEC	1510-27-9106	5.000
C900	(O)CAP,CER,6.2pF, 200V,+-.5pF,CHIP,NPO CASE=0805	C0805C629D2GAC	KEMET	1510-03-6629	1.000
C912 C918 C919 C920 C922 C923 C924 C925 C926 C927 C928 C929 C931 C932 C933 C934 C935 C936 C937 C948 C949 C950 C951 C953 C954 C955 C956 C957 C958 C959 C960	(P)CAP,CER,100PF,50V 1%,CHIP,NPO,+1-30PPM 0805,T/R,VALUE MARKD	C2012C0G1H101FT	TDK	1510-06-5101	31.000
C914 C942 C944 C946	CAP,TANT,1 UF,35V SURFACE MOUNT	NRB105M35R12	NEC	1510-27-9105	4.000
CR800 CR801 CR802 CR803 CR804 CR810 CR811 CR812 CR815 CR816 CR821	DIODE,PIN,GP,ODS-07 V=100V,CJ=0.4pF *SS*,T/R	HSMP3800L31	H-P	4805-02-0016	11.000
CR817 CR818 CR819 CR825	DIODE,HOT CAR,SOT-23 SMD,V=4VCT=1pF,*SS*	MMBD101	MOT	4809-02-0015	4.000
CR820 CR823 CR824	DIODE,PLANAR,HI SPD SWIT,SOT-23,V=75,IO= 250m,SUR,*SS*,T/R	BAS16 TRL	APX	4812-02-0005	3.000
CR822	DIODE,ZENER,*SS*,T/R 350mW,SOT-23,V=4.7 +/-5%	BZX84C4V7-TRL	APX	4801-02-0010	1.000
IC802	WIDEBAND AMP,20 DB 600 MHZ BW,SO-8 PKG	NE5205D	SIG	7000-52-0500	1.000
IC806 IC808	DUAL JFET INPUT OP AMP,SO-8*SS*	MC34002AD	MOT	7003-40-0210	2.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
IC807	ANLG SW.,QUAD, SPST, PLAS,SO-16,CMOS	DG201ADY	SCX	8000-02-0102	1.000
IC900	OCT,3-ST D-FLIP FLOP PLAS,SO-20,*SS*,HCMOS	MC74HC574DW	MOT	8007-45-7411	1.000
IC901	BUF,OCT,3 STATE, PLAS,SO-20,*SS*,HCMOS	MC74HC541DW	MOT	8007-45-4111	1.000
IC902	DCDR/DEMUX,1-OF-8, PLAS,SO-16,H-SPD, CMOS,*SS*	MC74HC138D	MOT	8007-41-3812	1.000
IC904	VOLTAGE REG PLAS, SO-8,5V,100MA,5%	MC78L05ACD	MOT	7000-78-0511	1.000
IC906	-15V VOLTAGE,REG,PLS PLAS,20-8,*SS*, Io=100mA	MC79L15ACD	MOT	7000-79-1511	1.000
L800 L801 L803 L900 L901	CHOKE,CHIP,1 UH,20% MOLDED,.18"L X .12"W T/R	LEM4532T1ROM	TAIYO	1816-02-0102	5.000
L802 L804 L813	CHOKE,CHIP,68nH,5%, .12"LX.10"W,MOLDED, T/R	SM3-068J	GWNDA	1816-01-0680	3.000
L805 L806 L807 L808 L809 L810 L812	CHOKE,CHIP,100UH,10% MOLDED,.18"L X .12"W T/R	LEM4532T101K	TAIYO	1816-02-0104	7.000
L811 L904 L905 L906 L907 L908 L909 L910 L911 L912 L913 L914 L915 L916 L917 L918 L919 L920 L921 L922 L923 L924	BEAD,SHIELD,SURF MNT TAPE & REEL	2743019447	FRTE	1813-00-0111	22.000
MX800	MIXER,SURFACE MOUNT 500 MHZ,*SS*	SCM-1NL,CASE YY101	MIN-C	3010-54-0016	1.000
Q800 Q802	FET,SOT-23,UHF/VHF, V=25,ID=60MA,P=350MV TAPE/REEL, *SS*	SST310	SCX	4902-00-3100	2.000
Q801 Q803 Q808 Q904 Q906 Q907 Q908 Q909	NPN,SOT-23,MED PWR F=250m,V=40,P=310m, hFE=40,*SS*,T/R	BSS79CE6237	SIEM	4902-00-0170	8.000
R800 R802 R826 R831 R841 R850 R852 R857 R864 R866 R899 R913 R924 R941	(P)RES,CHP,100,1% 1/8W,TC=100ppm,T/R 1206	RMC1810091C	KMYO	4711-03-1000	14.000
R801 R803 R805 R808 R810 R811 R828 R870	RES,CHP,66.5,1% 1/8W,TC=100ppm,T/R 1206	RMC1866581C	KMYO	4711-03-6659	8.000
R806 R807 R816 R818 R833 R853 R854 R858 R860 R862 R865 R921	RES,CHP,294,1% 1/8W,TC=100ppm,T/R 1206	9C12063A2940FKR	M-E	4711-03-2940	12.000
R809	(S)RES,CHP,178,1% 1/8W,TC=100ppm,T/R 1206	RMC1817891C	KMYO	4711-03-1780	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
R813 R814 R823 R838 R845 R859 R871 R919 R940	(S)RES,CHP,51.1,1% 1/8W,TC=100ppm,T/R 1206 CASE	RMC1851181C	KMYO	4711-03-5119	9.000
R815 R847 R882 R885	(P)RES,CHP,150,1% 1/8W,TC=100ppm,T/R 1206	RMC1815091C	KMYO	4711-03-1500	4.000
R822 R834 R903*	RES,CHP,499K,1% 1/8W,TC=100ppm,T/R 1206	RK73H2B4993F	KOA	4711-03-4993	3.000
R825 R846	(P)RES,CHP,10.0,1% 1/8W,TC=100ppm,T/R 1206	RMC1810081C	KMYO	4711-03-1009	2.000
R830 R848 R890 R915	(S)RES,CHP,475,1% 1/8W,1206,TC=100 PPM T/R	RK73H2B4750F	KOA	4711-03-4750	4.000
R832 R842	(S)RES,CHP,681,1% 1/8W,TC=100ppm,1%1206	RMC1868191C	KMYO	4711-03-6810	2.000
R836 R837 R839 R883 R886 R907 R910	(P)RES,CHP,10.0K,1% 1/8W,TC=100ppm,T/R 1206	RMC1810021C	KMYO	4711-03-1002	7.000
R840	RES,CHP,1.40K,1% 1/8W,TC=100ppm,T/R 1206	IMS-010-2-1401-F	IMS	4711-03-1401	1.000
R843 R898 R906 R908 R909	RES,CHP,4.99K,1% 1/8W,TC=100ppm,T/R 1206	RMC1849911C	KMYO	4711-03-4991	5.000
R844*	RES,CHP,14.7K,1% 1/8W,TC=100ppm,T/R 1206	RMC1814721C	KMYO	4711-03-1472	1.000
R884 R888 R893 R894	(S)RES,CHP,332K,1% 1/8W,1206,TC=100 PPM T/R	RK73H2B3323F	KOA	4711-03-3323	4.000
R887 R889 R892 R896 R902 R904 R905 R911	(P)RES,CHP,100K,1% 1/8W,TC=100ppm,T/R 1206	RMC1810031C	KMYO	4711-03-1003	8.000
R891	(S)RES,CHP,30.1,1% 1/8W,TC=100ppm,T/R 1206	RMC1830181C	KMYO	4711-03-3019	1.000
R895	(P)RES,CHP,20.0K,1% 1/8W,TC=100ppm,T/R 1206	RMC1820021C	KMYO	4711-03-2002	1.000
R897*	(S)RES,CHP,1.0M,1% 1/8W,1206,TC=100PPM T/R	RK73H2B1004F	KOA	4711-03-1004	1.000
R912	(S)RES,CHP,68.1K,1% 1/8W,1206,TC=100 PPM T/R	RK73H2B6812F	KOA	4711-03-6812	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
1	HYBRID PTS KIT, CONTROL BD, 24XXA	1219-00-0804	W-I	1219-00-0804	1.000
2	SCREW,STNLS,PPH,4-40 X 1/4	23022	F-S	2810-23-0064	3.000
3	LOCK WASHER,NO.4 CRES.INT.STARSTNLS.	99402	F-S	2810-28-0047	3.000
4	HEX NUT 4-40 CRES. STNLS.	70202	F-S	2810-16-0023	3.000
5	CARD EJECTOR-BLUE FROM:2810-12-0050	2810-12-0113	W-I	2810-12-0113	2.000
6	EYELET,3/32X3/16	SE36	F-S	2810-10-0020	2.000
7	SCW,4(TYP-B)X.25 LG, PPH,STAIN. STEEL	PER 2810-22-0012	F-S	2810-22-0012	2.000
10	THERMALCOTE THERMAL JOINT COMPOUND	THERMALLOY INC	ANY	1610-04-0015	0.001
11	RTV	3145	DOWCG	1610-03-0011	0.100
C290	CAP,TNT,1uF,25V 10%,AXL.095"Dx.260"L	173D105X9025U	SPR	1510-21-7010	1.000
CR201 CR202	DIODE,SIGNAL,GP AXIAL,V=75V,IO=10mA CT=4pF,*SS*	1N914	G-E	4807-01-0914	2.000
IC212	VOLT REG,+12V,3-TERM PLAS,TO-220,35Vdc Io=500mA,*SS*	LM78M12CT	NAT	7000-78-1200	1.000
IC213	VOLT,REG,FIXED,-15V PLAS,TO-226AA,-35Vdc 10%,Io=100mA,*SS*	LM79L15ACZ	NAT	7000-79-1510	1.000
IC214	VOLT REG,FIXED,+15V PLAS,3 PIN(TO-220) 35Vdc,.1%,700mA,*SS*	LM78M15CT	NAT	7000-78-1500	1.000
IC215	POS. VOLT REG-3 TERM PLAS,TO-220AB,5 VOLT 500mA,7 W,5%,3-TERM	UA78M05CKC	T-I	7000-78-0500	1.000
IC236	OP AMP,LOW NOISE PLAS,DIP-8,20Vdc 200KHz,13V/uS,*SS*	NE5534AN	SIG	7000-55-3401	1.000
IC247	PREC TEMP SENSOR PLAS,TO-92,If=15mA Ir=15mA,+-2C,*SS*	LM335Z	NAT	7000-03-3500	1.000
P200	D-CONN,96 PIN,RA, MALE,ROW A-C FILLED	DIN-96CPC-SRI-TR	R-N	2112-20-0007	1.000
P203	CONN,RF,RT.ANGLEJACK	700214	CBLWV	2110-08-0005	1.000
R267 R281	TRM,CM,L,5K,10%,PC 1T,PN,CW,.375H,.200W .375L,SA	3386S-1-502	BOU	4610-00-1502	2.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
RN216 RN222 RN228	RES,NW,4.7K,SIP,2% 1-1/4W,BUSSED,9 RES TC=100PPM	750-101-R4.7K	CTSBR	4770-00-0014	3.000
W01	WIRE,24GA,7/32,BLUE UL1430	1430-24-BL	ULSP	6013-32-4666	3.750

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
1	PCB,CONTROL,2407	1710-30-0094	W-I	1710-30-0094	1.000
C201 C202 C203 C211 C212 C213 C214 C217 C218 C230 C231 C238 C239 C245 C247 C248 C250 C251 C252 C253 C255 C256 C257 C258 C259 C260 C261 C262 C263 C264 C265 C266 C267 C268 C269 C270 C271 C272 C273 C274 C277 C283 C284 C285 C286 C287 C288	(P)CAP,TNT,.1uF,50V +/-20%,CHP,T/R, 1206 CASE	TAJA104M050R	AVX	1510-27-9104	47.000
C204 C206 C208	CAP,TANT,10 UF,25V SURFACE MOUNT,T/R	NRD106M25R12	NEC	1510-27-9106	3.000
C205 C207 C209 C210 C219 C220 C223 C226 C227 C229 C234 C237 C240 C241	CAP,TANT,1 UF,35V SURFACE MOUNT	NRB105M35R12	NEC	1510-27-9105	14.000
C221 C222 C224 C225 C232 C233 C235 C236	CAP,CER,.01uF,50V 10%,CHP,X7R,13"RL .08"x.05"CASE,T/R	C0805C103K5RAC	KEMET	1510-02-6103	8.000
C228	(P)CAP,CER,22PF,50V 1%,CHIP,NPO,+/-30PPM 0805,T/R,VALUE MARKD	C2012COG1H220FT	TDK	1510-06-5220	1.000
C246 C249 C254	(C)CAP,POR,5.1pF,50V +/-.25,CHP,NPO .07"x.055"	MA585R1C	MURGA	1510-02-9519	3.000
C289	(P)CAP,CER,100PF,50V 1%,CHIP,NPO,+1-30PPM 0805,T/R,VALUE MARKD	C2012COG1H101FT	TDK	1510-06-5101	1.000
IC201	FLOUR DISPLAY DRVR *SS*	UDN-6118A	SPR	8000-61-1800	1.000
IC202 IC203 IC205 IC206 IC224 IC248 IC249	OCT 3-STATE NON-INV D-TYPE FLIP-FLOP*SS* PLASTIC,DIP-20 CMOS	MC74HC574N	MOT	8007-45-7410	7.000
IC204 IC211	DCDR/DEMUX,1-OF-8 PLAS,DIP-16 H SPD CMOS,*SS*	MC74HC138N	MOT	8007-41-3811	2.000
IC207 IC208 IC228 IC229	BUFFER,OCTAL,3 STATE PLAS,DIP-20,*SS* HIGH SPEED CMOS	MC74HC541N	MOT	8007-45-4110	4.000
IC216 IC219 IC243 IC246 IC253	OP AMP,JFET,DUAL PLAS,DIP-8,22Vdc 10V/uS,LOW OFST,*SS*	LF412CN	NAT	7000-04-1210	5.000
IC217	MULTIPLEXER,4/8 CHAN PLAS,DIP-16,+-17Vdc CMOS,30uW,R=170,*SS*	AD7501JN	A-D	7000-75-0110	1.000
IC218	MULTIPLYING,DAC PLAS,DIP-18,17Vdc CMOS,12 BIT,*SS*	AD7541AKN	A-D	7000-75-4110	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
IC220	VOLT COMPARATOR PLAS,DIP-8,Tr=200nS *SS*	LM311N	NAT	7000-03-1100	1.000
IC221	EXCL-OR G,QUAD 2 INP PLAS,DIP-14, H SP CMOS,*SS*	SN74HC86N	T-I	8000-74-8611	1.000
IC222 IC233	NAND GATE,QUAD 2-INP PLAS,DIP-14,*SS* H-SPD CMOS-LSTTL	MC74HC00N	MOT	8000-74-0012	2.000
IC223	NAND G,TPL 3-INP PLAS,DIP-14,CMOS*SS*	TC74HC10P	TSHBA	8000-74-1001	1.000
IC225 IC226 IC227	UP/DWN CNTR,4 BIT PLAS,DIP-16,*SS* H-SPD CMOS,PRESETTBL	SN74HC191N	T-I	8007-41-9110	3.000
IC230	CNTR,BIN RPL,DUAL PLS,DIP-16 H SPD CMOS,*SS*	MM74HC390N	NAT	8007-43-9011	1.000
IC234 IC235	OP AMP,DUAL,LW NOISE PLAS,DIP-8,18Vdc 140KHz,9V/uS,*SS*	NE5532AN	SIG	7000-55-3201	2.000
IC237 IC238	ANLG SW,QUAD,SPST CERM,DIP-16,CMOS*SS*	DG201ACJ	SCX	8000-02-0101	2.000
IC239	OP AMP,LOW NOISE PLAS,DIP-8,20Vdc 200KHz,13V/uS,*SS*	NE5534AN	SIG	7000-55-3401	1.000
IC242 IC244 IC245	DAC,12BIT,UP,COMPAT PLAS,DIP-20,*SS*CMOS	MP1230KN	MCS	8001-20-3000	3.000
IC250	VOLT REF,PREC,10V PLAS,DIP-8,+-100mV *SS*	REF-01CP	PMI	7000-00-0101	1.000
Q201 Q202 Q203	NPN,SOT-23,MED PWR F=250m,V=40,P=310m, hFE=40,*SS*,T/R	BSS79CE6237	SIEM	4902-00-0170	3.000
R200 R208 R249 R259 R268 R269 R271 R272	(P)RES,CHP,1.0K,1% 1/8W,TC=100ppm,T/R 1206	RMC1810011C	KMYO	4711-03-1001	8.000
R201 R202 R204 R205 R206 R209 R212 R247 R250 R251 R260 R261 R265 R275 R279 R285 R286 R289 R291 R292 R293 R295 R296 R299	(P)RES,CHP,10.0K,1% 1/8W,TC=100ppm,T/R 1206	RMC1810021C	KMYO	4711-03-1002	24.000
R203 R258 R263	(S)RES,CHP,35.7K,1% 1/8W,1206,TC=100 PPM T/R	RK73H2B3572F	KOA	4711-03-3572	3.000
R207	(S)RES,CHP,1.0M,1% 1/8W,1206,TC=100PPM T/R	RK73H2B1004F	KOA	4711-03-1004	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
R210 R276	(S)RES,CHP,8.25K,1% 1/8W,1206,TC=100 PPM T/R	RK73H2B8251F	KOA	4711-03-8251	2.000
R211 R255 R290	(P)RES,CHP,5.11K,1% 1/8W,TC=100ppm,T/R 1206	RMC1851111C	KMYO	4711-03-5111	3.000
R213	(P)RES,CHP,2.00K,1% 1/8W,TC=100ppm,T/R 1206	RMC1820011C	KMYO	4711-03-2001	1.000
R246	(S)RES,CHP,332K,1% 1/8W,1206,TC=100 PPM T/R	RK73H2B3323F	KOA	4711-03-3323	1.000
R248	(S)RES,CHP,39.2,1% 1/8W,TC=100ppm,T/R 1206	RMC 1839281C	KMYO	4711-03-3929	1.000
R253 R273 R274 R277 R278	RES,CHP,14.7K,1% 1/8W,TC=100ppm,T/R 1206	RMC1814721C	KMYO	4711-03-1472	5.000
R262 R264	(P)RES,CHP,39.2K,1% 1/8W,1206,TC=100 PPM T/R	RK73H2B3922F	KOA	4711-03-3922	2.000
R266 R280	(S)RES,CH,6.81K,1% 1/8W,TC=100ppm,T/R 1206	RK73H2BT6811F	KOA	4711-03-6811	2.000
R270	(S)RES,CHP,511,1% 1/8W,TC=100ppm,T/R 1206	RMC1851191C	KMYO	4711-03-5110	1.000
R282 R283	RES,CHP,604,1% 1/8W,TC=100ppm,T/R 1206	RMC1860491C	KMYO	4711-03-6040	2.000
R284	(S)RES,CHP,13.0K,1% 1/8W,TC=100ppm,T/R 1206	RMC1/8 13.0K 1%	KMYO	4711-03-1302	1.000
R287 R294	RES,CHP,4.99K,1% 1/8W,TC=100ppm,T/R 1206	RMC1849911C	KMYO	4711-03-4991	2.000
R297	(P)RES,CHP,178K,1% 1/8W,TC=100ppm,T/R 1206	RMC1817831C	KMYO	4711-03-1783	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
2	HEX NUT 4-40 CRES. STNLS.	70202	F-S	2810-16-0023	1.000
3	SCREW,STNLS,PPH,4-40 X 1/4	23022	F-S	2810-23-0064	1.000
4	LOCK WASHER,NO.4 CRES.INT.STARSTNLS.	99402	F-S	2810-28-0047	1.000
5	CARD-EJECTOR-RED FROM:2810-12-0015	2810-12-0115	W-I	2810-12-0115	2.000
6	EYELET,3/32X3/16	SE36	F-S	2810-10-0020	2.000
7	IC SOCKET,20-PIN	C842002	T-I	2112-00-0020	1.000
8	IC, SKT,28-PIN	2-641267-1	AMP	2112-00-0023	2.000
9	HEATSINK FOR TO-220 PACKAGE OUTLINE	6079B	THR	2810-11-0045	1.000
10	SCW,4(TYP-B)X.25 LG, PPH,STAIN. STEEL	PER 2810-22-0012	F-S	2810-22-0012	2.000
A100	HYBRID PTS KIT, UPROC BD, 24XXA	1219-00-0805	W-I	1219-00-0805	1.000
IC101 IC121	MPU,CMOS PLAS,DIP-40,*SS*	HD63B03RP	HIT	8000-63-0310	2.000
IC104	8K X8 NON-VOL RAM PLAS,DIP-28,*SS*CMOS	DS1225Y-200	DLLAS	8000-12-2510	1.000
IC112	RAM DUAL PORT,1KX8 PLAS,DIP-48,CMOS*SS*	CY7C130-45PC	CYPRS	8000-71-3010	1.000
IC125	RAM CMOS,8KX8,DIP-28 120nS, *SS*	HM6264LP-12	HIT	8000-62-6400	1.000
IC126	ADPTR,GEN PURP INTFC PLAS,DIP-40,CMOS*SS*	MC68488P	MOT	8006-84-8810	1.000
IC130 IC131 IC132 IC133	XCVR,BIDRCT INST BUS PLAS,DIP-16,*SS*	MC3448AP	MOT	8000-34-4800	4.000
IC137	VOLT REG,5V,*SS* PLAS,TO-220,750MA W/DLYD RESET	LM2925T	NAT	7000-29-2510	1.000
P102	CONN,96 POS,DIN,M,RA 64 PIN,ROW B VOID	10-8457-096-002-026	ELCO	2112-20-0004	1.000
P111	HDR,DBL,RA,26-PIN	842-816-2633-435	APL	2112-08-0055	1.000
SW101	SWITCH,DIP,8 SPST	435802-1	AMP	5112-00-0004	1.000
TJ101	HDR,DBL,STRT,GOLD,16	65610-116	BER	2112-07-0079	1.000
X101 X102	CRYSTAL,3.579545 MHZ	MPC18-3.579545MHZ	NEL	2310-00-1190	2.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
1	OPEN END CVR,16,W/O	3452-6000	MMM	2112-29-0003	2.000
2	16 CONN RIBBON CABLE	499116-2	AMP	6011-60-0039	4.000

WAVETEK	JUMPER CABLE,2500	1219-00-0605	
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REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
1	PCB,DDS,2410A	1710-30-0142	W-I	1710-30-0142	1.000
2	EYELET,3/32X3/16	SE36	F-S	2810-10-0020	2.000
3	MICA INSULATOR	B08853A001	MOT	2810-11-0004	1.000
4	SHLDR WSHR,NYLON INSULATING BUSHING, TO-220	B51547F019	MOT	2810-11-0031	1.000
5	CARD EJECTOR-YELLOW FROM:2810-12-0048	2810-12-0114	W-I	2810-12-0114	2.000
6	NUT,4-40,HN101-400	8002A-NP	F-S	2810-14-4100	3.000
7	SCW,PPH,4-40X1/4	19022NP	F-S	2810-55-4104	3.000
8	IC SKT,PC,24-PIN .3 IN WIDE	ICO-243-S8A-T	R-N	2112-00-0079	3.000
9	SCW,4(TYP-B)X.25 LG, PPH,STAIN. STEEL	PER 2810-22-0012	F-S	2810-22-0012	2.000
C100 C101 C102 C103 C104 C106 C107 C108 C109 C110 C111 C112 C113 C114 C115 C116 C117 C118 C119 C120 C121 C122 C123 C124 C125 C126 C127 C128 C129 C136 C139 C140 C142 C143 C145 C146 C147 C162 C164 C165 C166 C167 C168	CAP,CER,.1uF,50V 20%,AXL,Z5U .10"Dx.26"L	SA205E1042AA	AVX	1510-17-1104	43.000
C130 C131 C132 C133 C134 C135	CAP,TNT,1uF,25V 10%,AXL.095"Dx.260"L	173D105X9025U	SPR	1510-21-7010	6.000
C137 C171	100 PF 20% 100V NPO AXIAL LEAD,TAPE/REEL	C410C101M1G5CA	KEM	1510-17-1101	2.000
C138	CAP,CER,1000PF,50V 1%,AXL,NPO,T/R .10"D X .17"L	SA105A102FAA	AVX	1510-17-5102	1.000
C141	CAP,CER,5.1pF,200V +/-.5pF,NPO,T/R .10"X.17L"	SA102A5R1DAA-T/R	AVX	1510-16-4519	1.000
C149 C153 C170	CAP,CER,470pF,50V 10%,AXL,NPO .09"Dx.16"L	592CC0G471J050B	SPR	1510-16-4471	3.000
C150	CAP,CER,75pF,50V 5%,AXL,NPO.09"Dx.16"L	C114G750J2G5CA	KEM	1510-16-8750	1.000
C151	CAP,CER,270pF,100V 5%,AXIAL,NPO,T/R	C410C271J1G5CA	KEMET	1510-17-1271	1.000
C152	CAP,CER,820pF,100V, 5%,AXL,NPO,T/R, .10"D X .17"L	SA101A821JAA	AVX	1510-16-4821	1.000
C154	CAP,CER,8200pF,50V, 10%,AXL,X7R,T/R .1"Dx.17"L	SA105C822KAA	AVX	1510-17-1822	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
C169	CAP,CER,220pF,100V, 5%,AXL,NPO,T/R, .1"D X .17"L	5A101A221JAA	AVX	1510-17-1221	1.000
IC100 IC101	MUX/SEL,QD 2-INP DAT PLAS,DIP-16 H SPD CMOS,*SS*	MC74HC157N	MOT	8007-41-5712	2.000
IC102	DCDR/DEMUX,1-OF-8 PLAS,DIP-16 H SPD CMOS,*SS*	MC74HC138N	MOT	8007-41-3811	1.000
IC103	BUFFER,OCTAL,3 STATE PLAS,DIP-20,*SS* HIGH SPEED CMOS	MC74HC541N	MOT	8007-45-4110	1.000
IC104 IC105 IC106 IC107 IC108 IC109 IC111 IC112 IC127 IC128	OCT 3-STATE NON-INV D-TYPE FLIP-FLOP*SS* PLASTIC,DIP-20 CMOS	MC74HC574N	MOT	8007-45-7410	10.000
IC113 IC114 IC117	ADDER,BCD,4-BIT,FULL HI-SPD,*SS*,PLAS, DIP-16,FAST	74F583PC	NAT	8007-45-8301	3.000
IC115 IC116 IC118 IC119 IC120	ADDER,BCD,4 BIT,FULL PLAS,DIP-16,*SS* H SPD CMOS	CD74HC583E	RCA	8007-45-8300	5.000
IC121 IC122 IC123 IC124	FF,OCT,COM CLK &RST PLAS,DIP-20 H SPD CMOS,*SS*	MC74HC273N	MOT	8007-42-7300	4.000
IC129	VOLT REG,-15V,3-TERM PLAS,TO-220,35Vdc 5%,1.5W,1.0A	UA79M15CKC	T-I	7000-79-1500	1.000
IC130	VOLT REG,FIXED,+15V PLAS,3 PIN(TO-220) 35Vdc,.1%,700mA,*SS*	LM78M15CT	NAT	7000-78-1500	1.000
IC131	POS. VOLT REG-3 TERM PLAS,TO-220AB,5 VOLT 500mA,7 W,5%,3-TERM	UA78M05CKC	T-I	7000-78-0500	1.000
IC132	12 BIT,A/D CONVERTER ULTRA HI-SPEED,*SS* MONO,CER,DIP-24	AD568JQ	A-D	7000-05-6800	1.000
IC133	OP AMP,WB,FAST SETLG PLAS,DIP-14, 400V/uS,400MHz,*SS*	HA2540-5	HSD	7000-25-4000	1.000
IC135	HEX INV,CMOS PLAS,DIP-14,*SS*	MC74HC04N	MOT	8000-74-0411	1.000
IC137	AND G,QUAD 2-INP PLAS,DIP-14 H-SPD CMOS,*SS*	MC74HC08N	MOT	8000-74-0812	1.000
IC138	QUAD TWO INPUT AND GATE,DIP-14,*SS*	74F08PC	NAT	8000-74-0802	1.000
IC139	FF,DUAL-D,W/SET&RST PLAS,DIP-14, H SPD CMOS,*SS*	MC74HC74	MOT	8000-74-7403	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
IC140	FF,DUAL-D,POS EDG TR PLAS,DIP-14, FAST SCHOT TTL, *SS*	74F74PC	FCD	8000-74-7402	1.000
IC141	EXCL-OR G,QUAD 2 INP PLAS,DIP-14,FAST*SS*	74F86PC	FCD	8000-74-8601	1.000
IC142 IC143 IC144	EXCL-OR G,QUAD 2 INP PLAS,DIP-14, H SP CMOS,*SS*	SN74HC86N	T-I	8000-74-8611	3.000
J100	CONN,SMA-F,50,PC MT RT ANG	42-302-1	CNTRS	2110-02-0017	1.000
L100	CHOKE,COATED,2.7UH 10%,D=0.120IN L=0.300IN,I=355MA	08N2R7	JEF	1810-03-0279	1.000
L101	CHOKE,COATED,2.2UH 10%,D=0.120IN L=0.300IN,I=395MA	08N2R2	JEF	1810-03-0229	1.000
P101	CONN,96 POS,DIN,M,RA 64 PIN,ROW B VOID	10-8457-096-002-026	ELCO	2112-20-0004	1.000
R100	(P)RES,MF,5.62K,1% 1/4W,AXL,TC=100ppmT/R	MF55D5621FL	KOA	4701-03-5621	1.000
R101 R103 R104 R105 R106 R107 R108 R109 R110 R111 R112 R113 R114 R115 R116 R117 R120 R121 R122 R123 R124 R125 R126 R127 R128 R129 R130 R131 R132 R133 R134 R147	(S)RES,MF,4.75K,1% 1/4W,AXL,TC=100ppmT/R	MF55D4751FL	KOA	4701-03-4751	32.000
R102	(S)RES,MF,4.42K,1% 1/4W,AXL,TC=100ppmT/R	MF55D4421FL	KOA	4701-03-4421	1.000
R136	(S)RES,MF,78.7,1% 1/4W,AXL,TC=100 PPM T/R	MF55D7879FL	KOA	4701-03-7879	1.000
R137	(S)RES,MF,1.21k,1% 1/4W,AXL,TC=100ppmT/R	MF55D1211FL	KOA	4701-03-1211	1.000
R138	(S)RES,MF,18.2,1% 1/4W,AXL,TC=100ppmT/R	MF55D1829FL	KOA	4701-03-1829	1.000
R139	(S)RES,MF,33.2,1% 1/4W,AXL,TC=100ppmT/R	MF55D3329FL	KOA	4701-03-3329	1.000
R140	(S)RES,MF,22.1,1% 1/4W,AXL,TC=100ppmT/R	MF55D2219FL	KOA	4701-03-2219	1.000
R141	(S)RES,MF,909,1% 1/4W,AXL,TC=100ppmT/R	MF55D9090FL	KOA	4701-03-9090	1.000
R142	(P)RES,MF,100,1% 1/4W,AXL,TC=100ppmT/R	MF55D1000FL	KOA	4701-03-1000	1.000
R145 R146	(S)RES,MF,51.1,1% 1/4W,AXL,TC=100ppmT/R	MF55D5119FL	KOA	4701-03-5119	2.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
IC125	EPROM,HIGH,2410 REF:8000-72-6310*SS*	8410-00-0121	W-I	8410-00-0121	1.000
IC126	EPROM,LOW,2410 REF:8000-72-6310*SS*	8410-00-0120	W-I	8410-00-0120	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
IC103	256K (32Kx8)COMS UV ERASABLE PROM *SS*	NMC27C256Q250	NAT	8002-72-5600	1.000
IC124	512K (64KX8)EPROM, 170NS OR FASTER DIP-28 *SS*	TMS27C512-17JL	T-I	8002-75-1200	1.000
IC128	PLD 2407 UPROCESSOR PGM COMDCD, REF:8000-32-0210*SS*	8410-00-0117	W-I	8410-00-0117	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
4	SCW,82 PFUCUT, 6-32X1/4	PER DESC2810-23-0096	F-S	2810-23-0096	6.000
5	SCW,PPH,6-32X3/16	19041NP	F-S	2810-55-6103	1.000
6	SEMS-PPH-INT 4-40 X 1/4 NPPER B/P	PER DESC2810-57-4104	F-S	2810-57-4104	9.000
7	SEMS-PPH-INT 4-40 X 1/2 NPPER B/P	PER DESC2810-57-4108	F-S	2810-57-4108	2.000
8	SEMS-PPH-INT 6-32 X 1/4 NPPER B/P	PER DESC2810-57-6104	F-S	2810-57-6104	12.000
10	ATTENUATOR BRACKET, 2410/2410R, FROM: 3210-02-0024	1410-30-9105	W-I	1410-30-9105	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
W06	(P)CABLE ASSY,2.5 IN SMA-SMA,.085"SOFT FM REF DWG:0012-10-0126	1217-91-0004	W-I	1217-91-0004	1.000
W07 W09	(P)CABLE ASSY,3 IN, SMA-SMA,.085"SOFT FM REF DWG:0012-10-0126	1217-91-0005	W-I	1217-91-0005	2.000
W08 W11	(P)CABLE ASSY,8 IN SMA-SMA,.085"SOFT FM REF DWG:0012-10-0126	1217-91-0015	W-I	1217-91-0015	2.000
W10	(P)CABLE ASSY,7.5 IN SMA-SMA,.085"SOFT FM REF DWG:0012-10-0126	1217-91-0014	W-I	1217-91-0014	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
W02	(P)CABLE ASSY,6.0 IN SMA-SMA,.141"CONFORM REF DWG:0012-10-0083	1217-92-0011	W-I	1217-92-0011	1.000
W24	RIBBON CABLE ASSY 20-PIN	1217-50-0010	W-I	1217-50-0010	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
P01	(P)CONN,SMA,50 OHM SLDR TYPE FOR .085"D SOFT FORM CABLE	142-0693-006	JON	2110-02-0002	1.000
R01	RES,C3,1/8W,1%.49.9	RF220-499	W-I	4706-03-4999	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
AT01	5P2410 SPECIAL T&M PROGRAMMABLE ATTEN	5P2410	W-I	1113-40-0201	1.000

WAVETEK PARTS LIST	ATTEN ASSY,2410	1219-00-0769 PAGE: 1	REV

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
1	CARD CAGE ASSY,24XXA	1216-00-0369	W-I	1216-00-0369	1.000
2	FOAM FILTER 1.20 X 1.05 FROM:3210-99-0050	1410-01-5160	W-I	1410-01-5160	2.000
3	FOAM FILTER, 1.20 X 6.95 FROM:3210-99-0050	1410-01-5170	W-I	1410-01-5170	1.000
4	ADHESIVE STRIP, .20"X.75"	1410-01-5180	W-I	1410-01-5180	4.000
5	ADHESIVE STRIP, .20"X6.80"	1410-01-5190	W-I	1410-01-5190	2.000
6	BOTTOM COVER, 24XX	1410-80-2510	W-I	1410-80-2510	1.000
7	FOOT,W/TIP-UP,BLACK	10603-025	SCHRF	2810-08-0029	2.000
8	FOOT,L=1.594,W=.748 BLACK W/LOCATOR TAB	10603-026	SCHRF	2810-08-0030	2.000
9	RIVET,AL,1/8X1/8	AD42ABS	USMFS	2810-30-0015	12.000
10	SEMS-PPH-INT 6-32 X 3/8 NPPER B/P	PER DESC2810-57-6106	F-S	2810-57-6106	4.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
1	PC BOARD,MOTHERBD, 2410A	1710-30-0165	W-I	1710-30-0165	1.000
2	SCREW,STNLS,PPH,4-40 X 1/4	23022	F-S	2810-23-0064	12.000
3	HEX NUT 4-40 CRES. STNLS.	70202	F-S	2810-16-0023	8.000
4	SHIELD,BACK LIGHT DRIVER	1410-60-4250	W-I	1410-60-4250	1.000
5	SCW,PPH,4-40X3/8 STAINLESS	23024	F-S	2810-23-0053	8.000
6	WASH,LOCK,SPLIT,4	1355	F-S	2810-28-0038	20.000
E1001	DC/AC INVERTER FOR EL,5V TO 100V AC, 400HZ *SS*	D32-43	OPTRX	3010-90-0058	1.000
J1001 J1002 J1003 J1004	D-CONN,96 PIN,ST FEM, ROW A-C FILLED	20-8457-096-001-025	ELCO	2112-20-0006	4.000
J1005 J1006 J1007 J1008 J1009 J1010	D CONN,37POS,STRT F SHIELDED,4/40 INSERT	H2R37ST28C	HLMBG	2112-04-0019	6.000
J1011	HDR,DBL,40-PIN SHRD,W/LATCH	80-40-013	WIN	2112-07-0102	1.000
J1012	HEADER,LOCKING,9-PIN .156"SPACING,RND PIN	3100-8-209-01	METH	2112-05-0001	1.000
J1013	HEADER,20-PIN ST W/ LATCH/SHROUDED	IDH-20PK2-S3-TG	R-N	2112-08-0082	1.000
J1014	HEADER,LOCKING,2-PIN .156"SPACING,RND PIN	3100-8-202-01	METH	2112-05-0010	1.000
J1015	CONN,RF,STR,JACK	09-1450-00C	PALCO	2110-08-0006	1.000
R1000	RES,WW,3W,1%,1	RS2B-3W-1-1%	DAL	4702-55-1008	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
3	BUTTON,SW(LT GRAY)	J52304 30656	C-L	5110-04-0019	1.000
4	KEYBOARD SPACER	1410-30-8790	W-I	1410-30-8790	1.000
5	L.WASHER.1/2,EXT HW106-001 MODIFIED IN SHOP	99150	F-S	2810-28-0023	1.000
6	1/8" SPACER	610-009	W-I	2810-05-0017	3.000
7	NUT,KEPS,4	71500	F-S	2810-16-0026	11.000
8	DISPLAY SHIELD	1410-30-9104	W-I	1410-30-9104	1.000
9	SCW,PPH,4-40X7/16	19025NP	F-S	2810-55-4107	4.000
10	SEMS-PPH-INT 4-40 X 1/4 NPPER B/P	PER DESC2810-57-4104	F-S	2810-57-4104	2.000
11	KEYPAD	5108-00-0014	W-I	5108-00-0014	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
2	DIODE,SIGNAL,GP AXIAL,V=75V,IO=10mA CT=4pF,*SS*	1N914	G-E	4807-01-0914	7.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
1	FRONT PANEL BRACE24XX	1410-30-8860	W-I	1410-30-8860	1.000
2	CARD CAGE ENCL GUIDE 24XX/24XXR	1410-30-8880	W-I	1410-30-8880	6.000
3	MALE-MALE THREADED ADAPTER #4-40	1410-30-8920	W-I	1410-30-8920	6.000
4	CARD CAGE,24XX/24XXR	1410-80-2480	W-I	1410-80-2480	1.000
5	CARD CAGE CENTER WALL,24XX/24XXR	1410-80-2520	W-I	1410-80-2520	1.000
6	CARD GUIDE,SLOTTED L=6.875,W=.375 MTG .4 CTRS W/O RVTS	PRD-6875	UTK	2112-16-0033	8.000
7	RIVET,AL,1/8X1/8	AD42ABS	USMFS	2810-30-0015	5.000
8	RIVET,SNAP-IN .060 THK CHASSIS FOR:2112-16-0033	RV4700	UTK	2810-30-0039	16.000
9	RIVET,POP,OPEN-END .125 BODY,CNTR SUNK GRIPRANGE,.251-.312	AK45BS	EMHFG	2810-30-0040	18.000
10	RIVET,POP,OPEN-END .125 BODY,CNTR SUNK, GRIPRANGE,.0635-.125	AK42BS	EMHFG	2810-30-0041	8.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
1	PC ASSY,P/S,24XXA	1110-00-2370	W-I	1110-00-2370	1.000
2	XFMR ASSY,24XXA	1219-00-0809	W-I	1219-00-0809	1.000
3	FAN ASSY,24XXA	1219-00-0811	W-I	1219-00-0811	1.000
4	GPIB CONN COVER PER B/P	1410-01-4980	W-I	1410-01-4980	1.000
5	FAN SCREEN FROM:3210-02-0571 PER B/P	1410-30-8240	W-I	1410-30-8240	1.000
6	FAN GASKET	1410-30-8930	W-I	1410-30-8930	1.000
7	REAR PANEL, 24XX	1410-80-2470	W-I	1410-80-2470	1.000
8	GROUND LUG,#6,INT HG102-600	38-111	F-S	2112-03-0003	1.000
9	FUSE,3AG,SB,1A,250V	MDL-1	BUS	2410-05-0005	1.000
10	FUSEHOLDER/PWR ENTRY MODULE	PE712003	CRTIS	2410-05-0045	1.000
11	CABLE CLAMP,1/4	8957	HHS	2810-00-0004	1.000
12	JACK SOCKET ASSY	3341-3KIT	MMM	2810-09-0035	1.000
13	KEP NUT8-32	9226	F-S	2810-15-0007	4.000
14	SCREW,PH,M3.5X.6X6MM	PER DESC2810-23-0122	S-S	2810-23-0122	2.000
15	HOLE PLUG, 1/2 BLK HB118-000	P500	HEYCO	2810-35-0001	1.000
16	HOLE PLUG,3/8 HB118-001	110-016	W-I	2810-35-0002	3.000
17	SEMS-PPH-INT 4-40 X 1/4 NPPER B/P	PER DESC2810-57-4104	F-S	2810-57-4104	4.000
18	SCW,PPH,8-32X1-3/4BK	19074-BK OXIDE	F-S	2810-65-8128	4.000
19	FAN GUARD	FF-325G	AFP	3010-13-0017	1.000
20	LINE CORD,3-COND,SVT 18 GA,7-1/2 FT,W/REC EUROPEAN COLOR CODE	6011-80-0006	ECMC	6011-80-0006	1.000
21	WIRE,18,UL1015,GN/YL	UL1015-18-GN/YL	ULSP	6013-11-8545	7.000
22	HEATSINK ASSY,24XXA	1216-00-0371	W-I	1216-00-0371	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
1	RIGHT & LEFT FRONT PANEL BEZEL,24XX FROM:3210-06-0055	1410-30-8830	W-I	1410-30-8830	2.000
2	BOTTOM FRONT PANEL BEZEL,24XX FROM:3210-06-0055	1410-30-8840	W-I	1410-30-8840	1.000
3	BEZEL,TOP FRONT PNL 2410A FROM:3210-06-0055	1410-30-9122	W-I	1410-30-9122	1.000
4	FRONT PANEL, 24XX FROM:3210-02-0029	1410-80-2460	W-I	1410-80-2460	1.000
5	SPACER,HEX,4-40X1/4 HD101-404	108301NP	F-S	2810-02-4104	4.000
6	SPACER,THD,4-40X1/2 HD101-408	108304NP	F-S	2810-02-4108	2.000
7	HANDLE,STYLE-Z,O-FINSH,.187"MOUNT FOR #8SCREW;BATCH/PAINT	15112-187-0	AMATM	2810-07-0020	2.000
8	NUT,KEPS,4	71500	F-S	2810-16-0026	10.000
9	NUT,KEPS,6	9225	F-S	2810-16-0027	6.000
10	SCW,PPH,8-32X5/16	19063NP	F-S	2810-55-8105	6.000
11	DECAL VALUE BAR 2410	2410-04-0799	W-I	2410-04-0799	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
AT01	5P2500 SPECIAL T&M PROGRAMMABLE ATTEN	5P2500	W-I	1113-40-0146	1.000
W15	ASSY, CABLE RIBBON 8.50 INCH LG,10 COND PER B/P 0012-10-0099	6011-60-0092	W-I	6011-60-0092	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
W01	(P)CABLE ASSY,7.5 IN SMA-N,.141" CONFORM REF DWG:0012-10-0084	1217-92-0053	W-I	1217-92-0053	1.000
W03	CABLE ASSY,6",BNC CABLE JACK TO SMB, RA PLUG	WX2407-W3	W-I	1217-80-0137	1.000
W20	CABLE ASSY,RIBBON 40-PIN,6 IN	6011-60-0096	W-I	6011-60-0096	1.000
W21	CABLE ASSY,RIBBON 16-PIN,3.5 IN	6011-60-0095	W-I	6011-60-0095	1.000
W26	POWER SWITCH/HARN ASSY,2407,26",W26	1212-00-0040	W-I	1212-00-0040	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
1	HEADER,RA,DBL,16-PIN REF:2112-08-0022	65624-416	BER	2112-08-0067	1.000
2	LCD,DOT MATRIX,40X2 SUPERTWIST,TOP VIEW EL BACKLIGHT *SS*	DMC40218NEU	OPTRX	2410-03-0025	1.000
W27	CABLE ASSY,DISPLAY TO MOTHER BD,2407	1217-50-0008	W-I	1217-50-0008	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
1	PCB,KEYBOARD,2407	1710-30-0099	W-I	1710-30-0099	1.000
J1111	HDR,DBL,40-PIN SHRD,W/LATCH	80-40-013	WIN	2112-07-0102	1.000
P1112	HDR,DBL,16-PIN SHRD,W/LATCH	80-16-013	WIN	2112-07-0101	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
1	TERM,LOOP,WIRE CRIMP 18-24GA	08-50-0106	MOL	2113-07-0002	5.000
P1300	JACK,FEMALE,5-CKT MC000-066	09-50-3051	MOL	2113-06-0008	1.000
T1300	POWER XFMR,115/230V +12.4 & +/-24.2V SEC PER B/P	BE 23163-001	BASLR	5610-00-0077	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
W04 W05	CABLE ASSY,BNC F TO SMA RA,RG174/U,16"	1217-50-0035	W-I	1217-50-0035	2.000
W22	CABLE ASSY,MOTHER BD TO PS BD,2407	1217-50-0003	W-I	1217-50-0003	1.000
W23	CABLE ASSY,GPIB,17in, 2407	1217-50-0005	W-I	1217-50-0005	1.000
W25	CABLE ASSY,10" POWER ENTRY MODULE,2407	1217-50-0002	W-I	1217-50-0002	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
3	GRIPLET-FUNNEL,.070 HT123-000	47299	BER	2112-19-0003	4.000
4	STANDOFF,SWAGE,.188, NO. 6	350-3928-10-07-00	CAM	2810-05-0015	2.000
5	SEMS-PPH-INT 4-40 X 1/4 NPPER B/P	PER DESC2810-57-4104	F-S	2810-57-4104	2.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
2	TERM,LOOP,WIRE CRIMP 18-24GA	08-50-0106	MOL	2113-07-0002	2.000
3	FAN,12VDC,80X80X25MM 25CFM	D31B10A4W3-000	TRW	3010-13-0018	1.000
P1301	CONN,FEMALE,2-PIN .156"SPACING,SNAP LK	09-50-3021	MOL	2113-06-0014	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
1	PCB,POWER SUPPLY2407	1710-30-0102	W-I	1710-30-0102	1.000
3	GRIPLET-FUNNEL,.070 HT123-000	47299	BER	2112-19-0003	4.000
4	STANDOFF,SWAGE,.188, NO. 6	350-3928-10-07-00	CAM	2810-05-0015	2.000
5	RTV	3145	DOWCG	1610-03-0011	0.100
C1300	CAP,ALM,4700uF,35V 80%,RAD 1.0 "DX1.6"LX.08"LS	80D472P035JC5	SPR	1510-27-7472	1.000
C1301 C1307	4700 PF 20% 100V X7R AXIAL LEAD,TAPE/REEL	C410C472M1R5CA	KEM	1510-17-1472	2.000
C1302 C1308	CAP,ALM,100uF,25V 20%,RAD	NRE101M25V	NIC	1510-23-4101	2.000
C1303 C1304 C1305	CAP,TNT,1uF,25V 10%,AXL.095"Dx.260"L	173D105X9025U	SPR	1510-21-7010	3.000
C1306	CAP,ALM,2700uF,35V 80%,RAD 1.0 "DX1.0 "LX.08"LS	80D272P035JA5	SPR	1510-27-7272	1.000
C1309	CAP,ALM,10000uF,16V +-20%,RAD 1.0"DX1.38"LX.08"LS	ECES1CV103S	PNSNC	1510-27-3103	1.000
C1310 C1311	CAP,TNT,10uF,25V, 20%,AXL,D=3% .18"x.345"	173D106X9025W	SPR	1510-21-7100	2.000
CR1300	DIODE,RECT BRDG,GP V=100V,IO=4A,IS=200A	KBL01	G-I	4806-02-0020	1.000
CR1301 CR1303	DIODE,SIGNAL,GP AXIAL,V=75V,IO=10mA CT=4pF,*SS*	1N914	G-E	4807-01-0914	2.000
CR1302 CR1304 CR1308 CR1309	DIODE,RECT,GP DO-15,V=400V,IO=1.0A *SS*,TAPE&REEL	1N4004	MOT	4806-01-4004	4.000
CR1305 CR1306	DIODE,RECT,GP AXIAL,V=200,IO=5.0A SUR I=225A,*SS*	1N5624	G-E	4806-01-5624	2.000
CR1307	DIODE,ZENER,1W,GP DO-41,V=12,IT=21mA IF=76mA,+/-5%,*SS*	1N4742A	MOT	4801-02-0003	1.000
IC1300	5V PREC VOLT REF,.3% PLAS,DIP-8,30Vdc W/TEMP TRANSDR,*SS*	REF02CP	PMI	7000-00-0203	1.000
IC1301	OP AMP,JFET INPUT PLAS,DIP-8,18Vdc 13V/uS,*SS*	TL082CP	T-I	7000-00-8200	1.000
J1300	HEADER,LOCKING,5-PIN .156"SPACING,RND,PIN	3100-8-205-01	METH	2112-05-0006	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
J1301	HEADER,LOCKING,2-PIN .156"SPACING,RND PIN	3100-8-202-01	METH	2112-05-0010	1.000
J1302	HEADER,LOCKING,9-PIN .156"SPACING,RND PIN	3100-8-209-01	METH	2112-05-0001	1.000
Q1300	JFET-N,TO-92,AUD AMP VGS=40,IDSS=10mA P=350mW,*SS*	2N5459	MOT	4902-00-2320	1.000
Q1302	PNP,TO-92,GP AMP/SW F=300,V=40,Icex=50nA P=625mW,hFE=100,*SS*	2N3906	MOT	4901-03-9060	1.000
Q1304	NPN,TO-126,DRLNG PWR F=1M,V=80,Iceo=100uA P=40W,hFE=750, *SS*	MJE803	MOT	4902-00-8030	1.000
R1300	(P)RES,MF,1K,1% 1/4W,AXL,TC=100ppmT/R	MF55D1001FL	KOA	4701-03-1001	1.000
R1301	(P)RES,MF,47.5K,1% 1/4W,AXL,TC=100ppmT/R	MF55D4752FL	KOA	4701-03-4752	1.000
R1302	(P)RES,MF,3.92K,1% 1/4W,AXL,TC=100ppmT/R	MF55D3921FL	KOA	4701-03-3921	1.000
R1303	(P)RES,MF,13.0K,1% 1/4W,AXL,TC=100ppmT/R	MF55D1302FL	KOA	4701-03-1302	1.000
R1305 R1307 R1309	(P)RES,MF,10K,1% 1/4W,AXL,TC=100ppmT/R	MF55D1002FL	KOA	4701-03-1002	3.000
R1308 R1311	(S)RES,MF,4.75K,1% 1/4W,AXL,TC=100ppmT/R	MF55D4751FL	KOA	4701-03-4751	2.000
R1310	(S)RES,MF,1.24K,1% 1/4W,AXL,TC=100ppmT/R	MF55D1241FL	KOA	4701-03-1241	1.000
R1312	(S)RES,MF,825,1% 1/4W,AXL,TC=100ppmT/R	MF55D8250FL	KOA	4701-03-8250	1.000
R1313	(P)RES,MF,2.74K,1% 1/4W,AXL,TC=100 PPM T/R	MF55D2741FL	KOA	4701-03-2741	1.000
R1314	(P)RES,MF,499,1% 1/4W,AXL,TC=100ppmT/R	MF55D4990FL	KOA	4701-03-4990	1.000
R1316	(P)RES,MF,4.99K,1% 1/4W,AXL,TC=100ppmT/R	MF55D4991FL	KOA	4701-03-4991	1.000

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY
1	PS HEATSINK,2407	1410-01-5150	W-I	1410-01-5150	1.000
2	MICA INSULATOR	B08853A001	MOT	2810-11-0004	3.000
3	SHLDR WSHR,NYLON INSULATING BUSHING, TO-220	B51547F019	MOT	2810-11-0031	3.000
4	SCW,PPH,4-40X1/4	19022NP	F-S	2810-55-4104	3.000
IC1302	ADJ REG,1.2V-37V PLAS,TO-220,1.5A=Io 15W,0.1%,*SS*	LM317T	NAT	7000-03-1700	1.000
Q1301 Q1303	PROT PWR DARLINGTON *SS*	LM395T	NAT	4902-00-3950	2.000

WAVETEK PARTS LIST	HEATSINK ASSY,24XXA	1216-00-0371 PAGE: 1	REV